Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT
September 16, 1957 PRICE 50 CENTS

DESIGN edition

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Shock loading of bearings

Ford's newest — the Edsel . . . see page 5

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Not from a foreign foe. Not from a crackpot's bomb. This peril was less exciting . . . *but no less destructive.*

It was corrosion — corrosion that had been at work ever since Liberty first raised her torch.

Relentless and merciless in attack, the acrid, smoggy sea air of New York harbor had loosened and weakened the rivets holding the statue's huge sheet metal plates together.

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Nickel Alloys Perform Better, Longer

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

September 16, 1957 Vol. 28, No. 10

Cast Urethane Rubber— 68... R. H. Kittner, K. A. Pigott, Mobay Chemical Co.
American production of abrasion-resistant material is ready to roll. Material properties, performance and design tips.

How to Reduce Shock Loads in Bearing— 72... R. H. Carter, Miniature Precision Bearings, Inc.
Roundup of methods for reducing effects of overload.

Surface Finish—How It Is Measured— 77... R. E. Reason, Taylor, Taylor & Hobson, Ltd.

—Tolerance and Cost— 82... K. S. Collart, Brush Electronics Co.
What it is and how it's measured; significance of cutoff and waviness; applications, specifications.

Cams and Gears— 84... J. S. Beggs, Univ. of Calif., and R. S. Beggs, Hughes Aircraft Co.
New intermittent mechanism reduces shock in starting and stopping high-speed equipment.

Design Features in New Products— 86...
Compact transmission; 20-high rolling mill; the new Edsel; hydraulic steering; preloaded bearings; exhaust-driven turbine.

Welded Magnesium Castings— 94... H. Mansfield and L. Gesualdo, Wright Aeronautical Div.
Process permits minor metal additions without distortion.

Lower-speed Motors— 96... Charles C. Libby, Fairbanks, Morse & Co.
Select on the basis of speed rather than inertia for high-duty drives.

SPECIAL REPORT

Engineering Models— 99... staff report.
Spatial relationships seen "in the round" save money. Colorful models graphically illustrate function, assembly and maintenance.

New Pressure-sensitive Material—106... Dudley B. Clark, Clark Electronic Laboratory.
Cells serve as force transducers to operate relays without amplification.

Critical Frequencies of Torsional Systems—110... M. F. Spotts, Northwestern Univ.
Quick approximations reduce calculation for many cases.

Titanium-clad Steel—111... R. F. Domagala, D. Levinson, W. Rostoker, Armour Research.
Progress report on roll-cladding steel with a thin layer of titanium.

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Malfunction Ball Bearings—122... Howell L. Potter, Fafnir Bearing Co.
14 examples of bearings that do more than one job.

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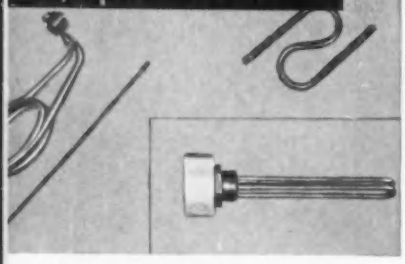
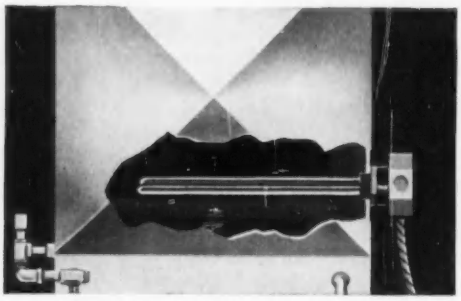
DESIGNING HEAT INTO YOUR PRODUCT?

General Electric Metal-sheath Heaters Save Time in Both Production and Design

HEATING LIQUIDS



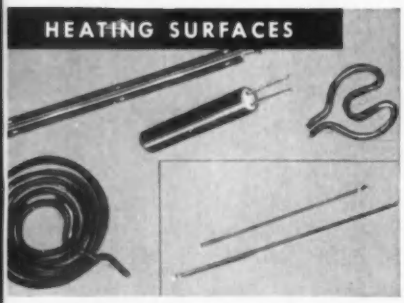


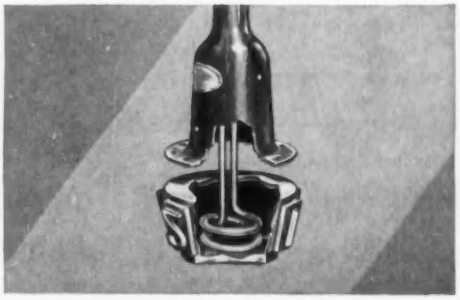
1 **DISHWASHER MAKER CHOSE** screw-in type G-E immersion heater from wide variety available. Threaded fitting speeds installation.

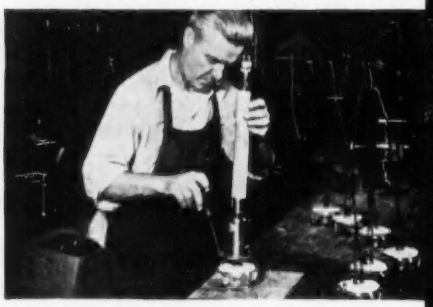
2 **DIRECT CONTACT WITH LIQUID** over entire heating surface provides fast heat-up and minimizes heat-transfer losses. Thermostat is easily installed for temperature control.

3 **SIMPLE ELECTRICAL CONNECTIONS,** after heater is screwed into place, complete installation. Assembly is fast, easy.

HEATING SURFACES





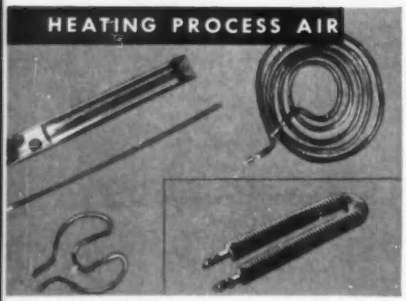


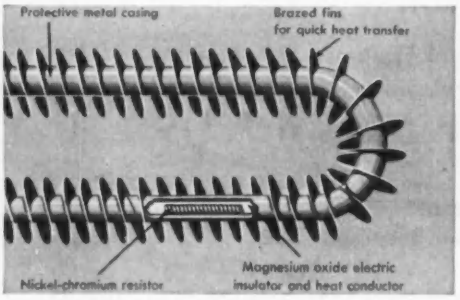
1 **EASILY FORMED WITHOUT BREAKING** . . . this is reason why General Electric tubular heaters are choice of branding-iron manufacturer.

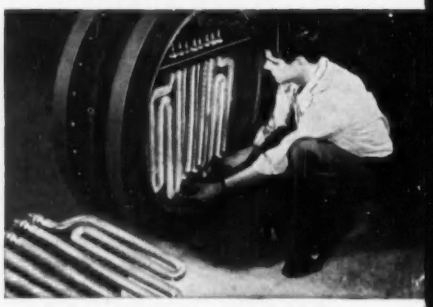
2 **STURDY METAL SHEATH** permits casting heaters right into die body—without production headaches. Result is dependable, even heating of entire die surface.

3 **LONG LIFE** comes from combining quality die work with dependable G-E heaters. Users report up to 12 years life.

HEATING PROCESS AIR




Protective metal casing
Brazed fins for quick heat transfer
Nickel-chromium resistor
Magnesium oxide electric insulator and heat conductor



1 **LARGE RADIATING SURFACE** per unit length of G-E finned tubular heaters allows maximum air circulation in forced-convection heating.

2 **COMPLETELY ENCLOSED** heating element of General Electric finned heaters is protected from dust in the air stream, eliminating trouble from short circuits.

3 **PRE-FORMING TO YOUR SPECS** reduces on-site fabrication time and costs, and helps solve problems of installation.

HANDY SELECTOR GUIDES . . .

Learn how to pick the right G-E heater for your job.

NAME.....

COMPANY.....

ADDRESS.....

CITY..... STATE.....

Mail to Section J 723-11, General Electric Company, Schenectady 5, N. Y.

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- ☐ **GEA-6146 Handy Selector Guide for Surface Heating**
- ☐ **GEA-6305 Handy Selector Guide for Water, Alkaline or Plating Baths**
- ☐ **GEA-6306 Handy Selector Guide for Heating Oil**
- ☐ **1957 Catalog of Heaters and Devices**

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Interesting to Note . . .

Edsel Enters the Race

THAT name "Edsel" was derived after a great deal of exploration. Eighteen thousand suggestions were received from all parts of the world, from persons in all walks of life. The final choice was between "Edsel," "Ventura" or "E-car" (for Experimental). Ford Motor unanimously picked the name of Henry Ford's only son, company president from 1919 until his death in 1943.

As a person, young Edsel never was able to escape the pressure of his father's dominance. Even as company president, his decisions on policy were supervised by "Old Henry." If he conceived a way of design or production opposed to his father's will, it was "discouraged." On one occasion Edsel experimented with a six-cylinder car at the Ford engineering laboratories. When his father heard of this, he went to the lab, grabbed an ax, and demolished the engine. Henry maintained that cars should only be made with 4, 8 or 16 cylinders. Another time, Bill Mayo, chief engineer, told Edsel that new coke ovens were needed. Edsel gave Mayo his approval. Henry said no. The ovens were built, then immediately torn down.

An experimental chassis of the Edsel appears on this issue's cover. Did you notice the compressor attached to the right side of the engine? It's for air suspension. Although not presently featured on the car, Ford engineers are working on it. The squared platform (left side of engine) held an air conditioner which was removed before the picture was taken for *Product Engineering*. More design data on the Edsel can be found on page 86.

The Model King

One of America's fastest growing hobbies is model building. Less than ten years ago, it was the youngster who bought a sheath of balsa sticks and a modified blueprint. Then after many hours of cutting, gluing and assembling, he ended up with a constructed model of the latest ship or airplane. Today, it's the plastic model kit. Kids from 8 to 80 can buy and easily assemble a highly accurate, scale model of Bill Hickok's .45 Colt, the Cadillac Brougham or a ready-to-run H-O electric train—to name but a few. The leading company in the plastic model business is Revell, Inc. It expects to sell close to 35 million kits this year.

In 1949, Lewis H. Glaser, president of the company, built a plastic model of Jack Benny's famous Maxwell. Glaser was then

(Continued on page 7)

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*$18.50 is the list price for the ¼" port size and $19.50 for the ⅜" less usual quantity discounts.

NO MORE

AIR VALVE

TROUBLES

FROM DIRT OR **CORROSION**

(AND WITHOUT COSTLY FILTERS AND OILERS)

Important Savings	Low initial cost. Need no oilers and filters (time and materials savings).	All components are corrosion resistant.
Low Maintenance	Sealing qualities do not diminish with long, continued use.	Wear compensating "Shear-Seal" design.
Long Service Life	No production delays. Maintenance (rarely needed), without disturbing plumbing.	Lapped metal to metal sealing members.
Not Critical to Dirt	No scoring or binding. (As with spool or poppet designs.)	Flow is through "Shear-Seals." Sealing surfaces remain in constant intimate contact.
No Creeping Cylinders	Leakproof closure. (No internal port to port leakage.)	Maintained through lapping action of each operation.

Ask for bulletin A-5.

Foot operated models with or without spring return to reverse or to center are $24.50 list for the ¼" and $25.50 for the ⅜" valve less quantity discounts.

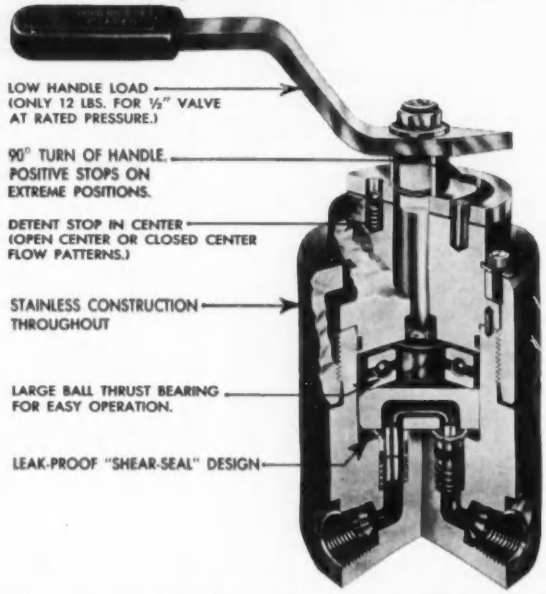
BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

This highly successful principle of extreme pressure control is fully described in "Shear-Seal" bulletin BVM-2.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

Interesting to Note . . . .

manufacturing small plastic toys. At the annual American toy fair, the Maxwell was a surprise hit. Almost overnight, Glaser left the toy business and began making the plastic model kits. The company will gross close to $17 million this year selling a line of 91 kits.

Scale models need not be toys. Working directly in three-dimension, the design engineer can avoid many of the pitfalls and hazards of two-dimensional drawings and photographs. As the article on page 99 proves, a fourth dimension—color—also lends brilliance.

Most Wonderful Thing in America

When Alexander Graham Bell uttered his now famous, "Mr. Watson, come here! I want you," his problems with the telephone were not over. The working principle has changed little, from his first instrument to today's phone, yet Bell had a king-sized job convincing the public that his invention was more than a mere gadget or toy.

The telephone was first exhibited in the summer of 1876 at the Centennial Exposition, Fairmount Park, Philadelphia. Sunday was judging day and the hottest day of the year. The judges, headed by Emperor Dom Pedro of Brazil, hurried from one exhibit to the next. At long last they came near the small table holding Bell's invention. Sir William Thompson (Lord Kelvin) paused and said, "Gentlemen, we will continue with our judging tomorrow. This American heat makes it impossible. . . ." Here was a great disappointment to Bell because he had to teach at the Boston School for the Deaf on the following day. As the judges turned to leave, Dom Pedro came face to face with Bell. He recognized him immediately as the man who had recently introduced new methods for teaching the deaf in Brazil. Despite the heat, the Emperor, Sir William and Dr. Joseph Henry (then head of the Smithsonian Institution), examined the telephone. Sir William called it "the most wonderful thing in America."

In the mouthpiece of the telephone is a pressure-sensitive device containing loosely packed carbon granules. Another device, using granules loose or in a binder, to vary electrical current in response to pressure, is discussed on page 106. It is capable of controlling power up to 200 watts or over and exploits possibilities of using rare earths in this control field.

Pyramid Problems

Of the world's great engineering feats, one of the least understood is the building of the Pyramids. Why were they built? Is there any correlation between their design and current or future events? And, of course, *how* were they built? It is known that the Egyptians must have had a high degree of accuracy in the technique of levelling. The perimeter of the bed of the Great Pyramid deviates from a truly level plane by only a little more than half an inch. However, the method used to convey the blocks of limestone, some over 200 tons, has thus far merely been conjectured.

It is assumed that the blocks were cut with copper tools, loaded onto ships and pulled up the Nile. Somehow, the gigantic stones were removed, then by use of wooden rollers aided by a liquid (probably water) to reduce friction, dragged to the pyramid. Raising the stone posed another unanswerable question. Herodatus believes that the ancients had "machines formed of short beams of wood." These machines were located on each step of the Pyramid and by employing slaves and the use of leverage, maneuvered the stones. Egyptologists are still trying to fathom this mystery.

Ancient carvings show primitive rollers and levers at work maneuvering the giant stones. The constant shock of tons of material upon these wooden rollers must have been tremendous. On page 72, an article describes methods of designing bearings to absorb shock imposed by modern heavy-duty machines.

Condamine—Adventurer or Scientist?

The year was 1735 when the French Academie des Sciences commissioned a five-man team of astronomers to go to Peru and measure an arc of the meridian by an "astronomy and Civil survey." The man heading this memorable assignment was a brash young *bon vivant*—Charles Marie de la Condamine. It took seven years before the team satisfied its scientific desires in Peru, at which time the members went their respective ways. Condamine, the adventurer, decided that he wanted to follow the path Pizarro took in 1541: over the mountains, through the jungle to the headwaters of the Amazon, then down to the Atlantic Coast.

His trip took him three years. But he did see first-hand a material with amazing properties. Native Indians had a substance that they turned into watertight shoes and bottle syringes—rubber. Condamine was not the first white man to come across natural rubber; however, he was the first to bring it to Europe. The Spaniards must have known of it, but they had come to South America for gold; Condamine was a scientist.

The advent of World War II dramatically brought to light the vital importance of rubber. As a result of research on synthetic rubber, a new family of high-polymer chemicals was born. A recent development in the elastomer field is urethane rubber, which provides the long-sought combination of hardness and abrasion resistance with the resilience of natural rubber. On page 68 is an article on how to design urethane-rubber parts.

—Benedict A. Leerburger Jr.

Mallory Gyromet*...

the Alloy for Future Gyroscopes

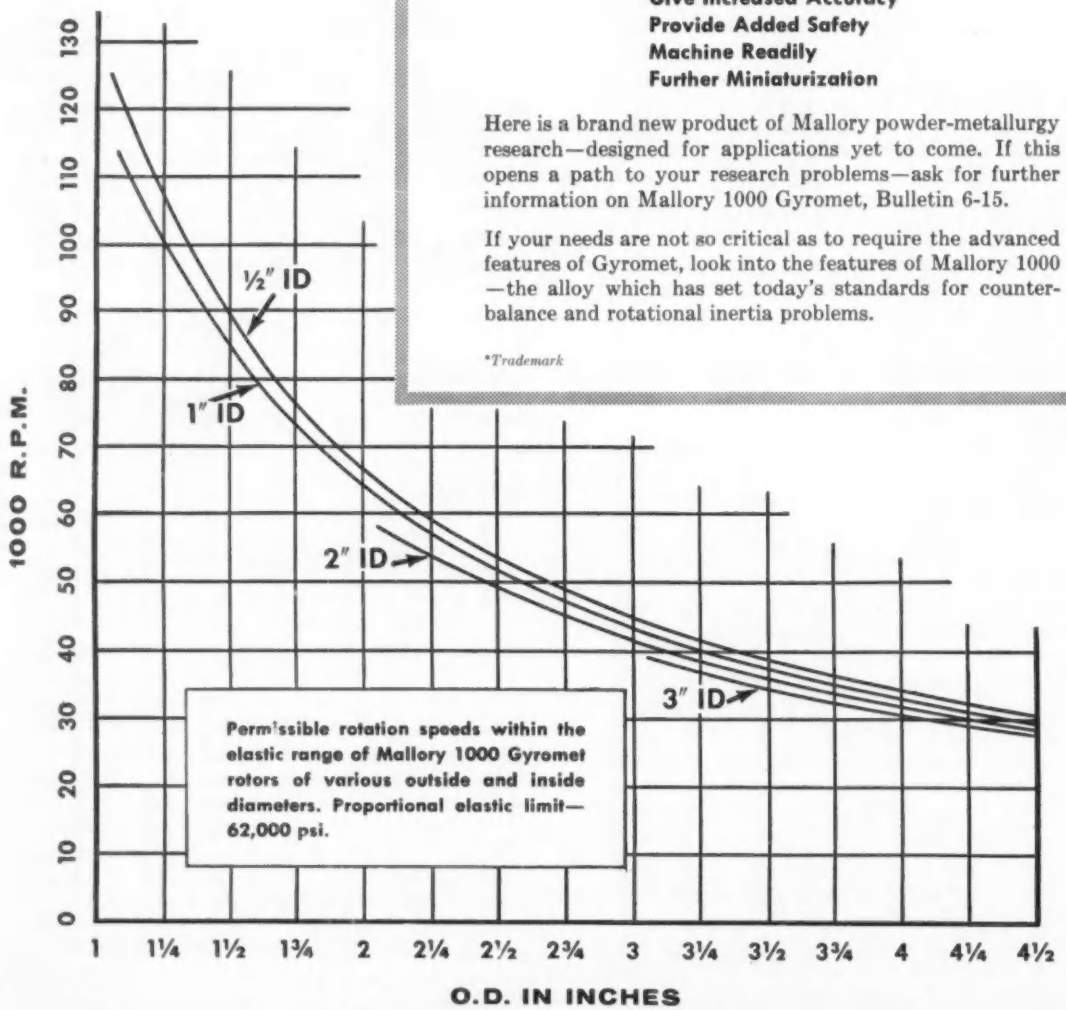
Gyromet—a new gyroscope material having higher tensile strength and greater elastic limit, will:

Rotate at Greater Speeds
Gain Greater Momentum
Give Increased Accuracy
Provide Added Safety
Machine Readily
Further Miniaturization

Here is a brand new product of Mallory powder-metallurgy research—designed for applications yet to come. If this opens a path to your research problems—ask for further information on Mallory 1000 Gyromet, Bulletin 6-15.

If your needs are not so critical as to require the advanced features of Gyromet, look into the features of Mallory 1000 —the alloy which has set today's standards for counter-balance and rotational inertia problems.

*Trademark



Permissible rotation speeds within the elastic range of Mallory 1000 Gyromet rotors of various outside and inside diameters. Proportional elastic limit—62,000 psi.

In Canada, made and sold by Johnson Matthey and Mallory Ltd., 110 Industry Street, Toronto 15, Ontario

Serving Industry with These Products:

Electromechanical — Resistors • Switches • Tuning Devices • Vibrators
Electrochemical — Capacitors • Mercury and Zinc-Carbon Batteries
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Expect more . . . get more from

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

Developments

To Watch

NEW SIGNALING DEVICES, LUMINESCENT PAINTS, FLASHLIGHTS . . .

. . . and luminescent paneling are on the way if the AEC's predictions as to price and availability of radioactive fission products come true. Three isotopes, krypton 85, cesium 137, and strontium 90 are expected to be a lot cheaper in the near future. Right now, they cost from $10 to $50 a curie (the index of radioactivity), but new processing plants scheduled to open this fall are expected to increase supply and lower prices around 30%, and AEC Commissioner Willard Libby quotes "rock-bottom" prices, possible within the next decade, of 4 to 50 cents.

SELECTIVE ADHESION OPENS NEW HORIZONS . . .

. . . in product and package design. There are adhesives that stick to themselves and nothing else, adhesives that stick to almost anything, and now anti-adhesives that resist even the tackiest materials. Dow-Corning's new "ab-hesive" or "anti-adhesive" silicone compounds, for example, are said to "impart the highest order of surface resistance to sticky materials ever developed."

REMARKABLE NEW MATERIALS . . .

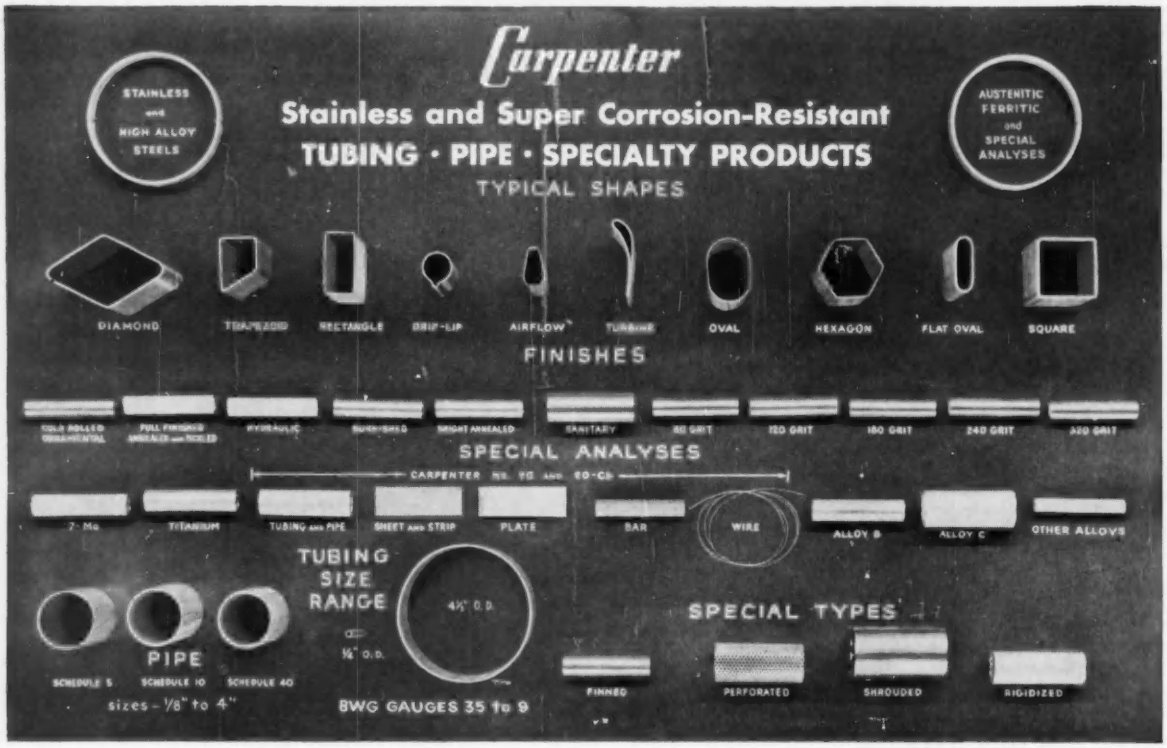
. . . are being created with the aid of high temperatures and high pressures. One example is cerium sulfide, a metal-like ceramic that resists temperatures to 4500 F and is so corrosion-resistant that it can be (and has been) used as a container for chemical experiments with plutonium.

But this is only a sample of a trend. Synthetic mica, diamonds, and the ultra-hard boron nitride, also stem from high-temperature research. And the top limits are constantly being extended. At Temple University's Research Institute, for instance, flames with temperatures well above 5500 F are produced with cyanogen-ozone mixtures; still higher temperatures—above 25,000 F—are being created in several laboratories by special arc techniques.

IF BETTER ENGINES ARE TO BE BUILT . . .

. . . a lot more will have to be learned about how fuels burn. That's just as true for standard piston engines and gas turbines as it is for rocket engines bound for outer space (Sept. 9, p. 16). In fuel injection, for example, it's important to know how long it takes for fuel droplets to form, vaporize, mix with air; and ignite. A GE approach to this problem is the shock tube setup shown here. Air at 500 psi bursts an acetate diaphragm, sending a shock wave down the tube at a velocity of 1000 mph. After the wave has been reflected from the other end, the fuel (heated above 600 F) is injected, and the reaction is photographed.

Shock wave . . .
in GE test setup bounces back in 50-ft tube to burn injected fuel. High-speed camera, left, records the test results at speeds up to 8000 frames a second.



Experienced hands at solving many corrosion and heat problems

Your choice of over 35 analyses for
• corrosion resistance • heat resistance
• light-weight strength

AISI TYPES			SUPER CORROSION-RESISTANT TYPES
302	310	321	Carpenter Stainless No. 20Cb
304	316	347	Carpenter 7Mo
304L	316Cb	348	Carpenter Alloy B
309	316L	430	Carpenter Alloy C
309S	317	442	Titanium 55 and 70
309SCb	317L	443	

Other specialty grades in various stages of development are available: Zirconium, Zircalloy II, 19-9 DL, Invar, HiMu80, N-155, Haynes No. 25 (L-605), Hastelloy F and Hastelloy X, Armco 17-7PH, Titanium alloys, A-286 and others.

Here's why it will pay you to consult Carpenter about corrosion and heat-resistant tubing for pressure, mechanical, structural and sanitary requirements: The wide variety of types, grades, shapes, finishes and sizes illustrated can be supplied in the many standard and specialty analyses listed above. You benefit from over a quarter century of experience in helping equipment designers and builders solve a vast assortment of corrosion and heat problems. Carpenter's meticulous quality control assures you of getting tubing and pipe of the highest possible degree of perfection. Technical and metallurgical assistance with your materials selection and fabrication and nation-wide service on your requirements are available through qualified Carpenter Distributors and Representatives in over 40 cities.

Put your problems in Carpenter's capable hands today. Ask for Bulletin T.D. 120.

MEMBER

The Carpenter Steel Company
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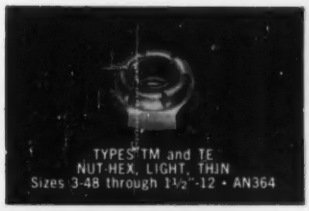
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

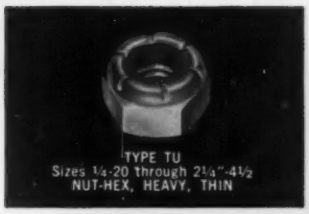
Carpenter

Stainless Tubing & Pipe

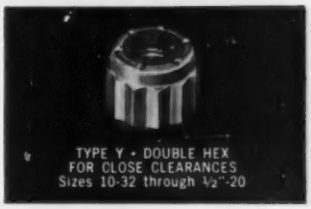
How does ESNA's complete line turn your special hex nut requirements into standard parts?

TYPE U
Sizes ¼-20 through 2¼"-4½
NUT-HEX, HEAVY


TYPES TM and TE
NUT-HEX, LIGHT, THIN
Sizes 3-48 through 1½"-12 • AN364


TYPE TU
Sizes ¼-20 through 2¼"-4½
NUT-HEX, HEAVY, THIN

TYPES M and E • NUT-HEX LIGHT
Sizes 1-72 through 1½"-12
AN365

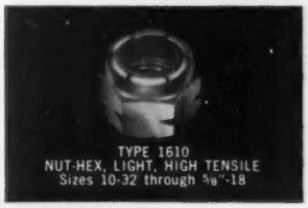

TYPE Y • DOUBLE HEX
FOR CLOSE CLEARANCES
Sizes 10-32 through ½"-20

The answer is: by manufacturing a complete line of hex nuts—that includes hundreds of dimensional, material and tensile variations.

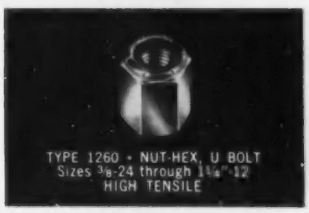
For example, all the nuts shown here are standard parts. Yet they range in size from a sub-miniature 0-80 thread that is only .107" across the flats to a 4"-4 thread 6-1/8" across. Thread series include SAE, USS and British BSF, BA and Whitworth series. Most are available in carbon steel, stainless, brass and aluminum. They do not gall or seize bolt threads, and they can be re-used many, many times.

Furthermore, the effectiveness of their red locking collars has been proved by more than thirty years of rugged field service—on locomotives, pile drivers, oil drilling machinery, washing machines, trucks and tractors.

These standard ESNA hex nuts are available from stock or are produced under normal lead times. And, of course, hundreds of other "specials" are also available. For details on the Elastic Stop® nuts shown here, write Dept. N47-722.


TYPE 1610
NUT-HEX, LIGHT, HIGH TENSILE
Sizes 10-32 through ⅝"-18

TYPE 1660 MINIATURE
Sizes 0-80 through 4/48


TYPE 1260 • NUT-HEX, U BOLT
Sizes ⅜-24 through 1¼"-12
HIGH TENSILE

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 Vauxhall Road

Union, New Jersey

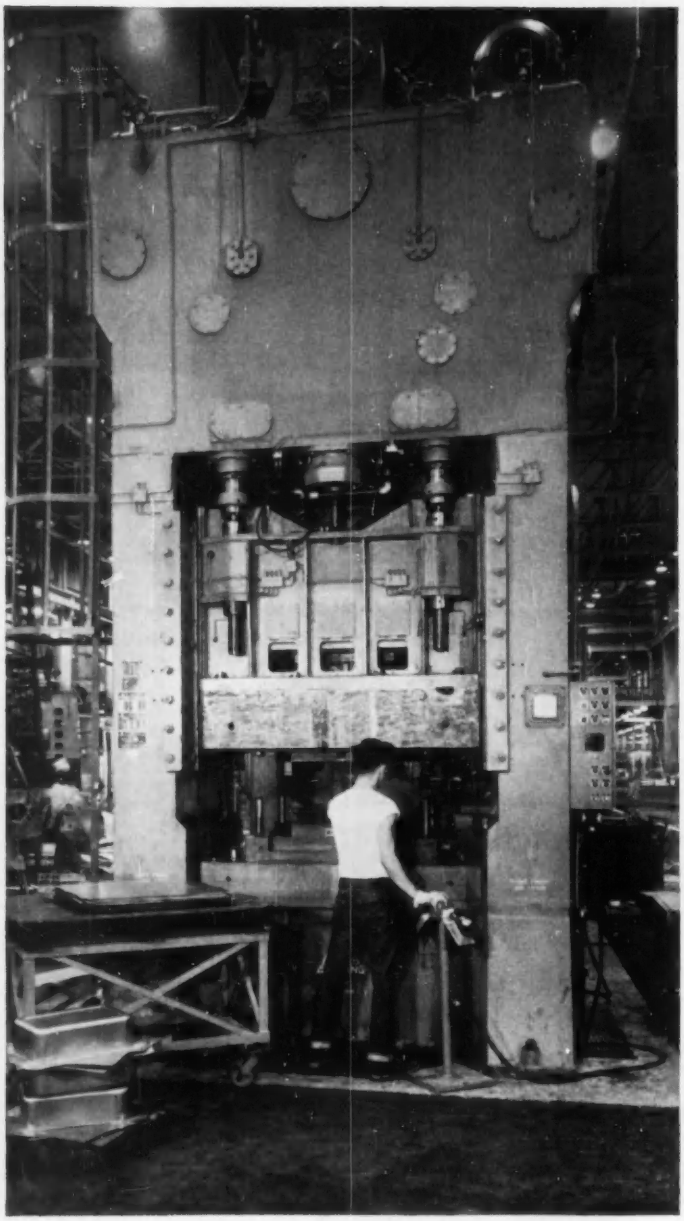
TYPE NKM-NKE
NYLON CAP-LIGHT-HEX NUT
•Sizes 6-32 through ½"-20

Westinghouse Press Control with

CYPAK

is three-ways safe...

for operator, machine and work.



Westinghouse Press Control with CYPAK* offers a new high in industrial safety for machine operator, the machine dies and blanks, and work material.

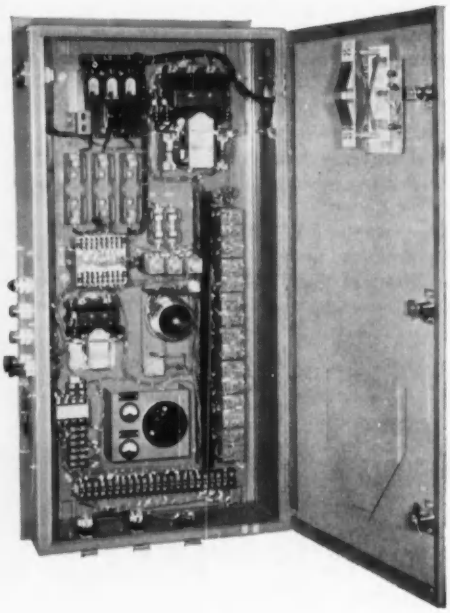
Because CYPAK eliminates the use of relays, there are no mechanical parts to stick or jam in the control and cause a repeat of the press. Patented anti-repeat clutch control circuit is self-checking, calling for two impulses to initiate a stroke.

Standard control has a four-position selector switch and run-pushbutton that are key-locked. An externally operated circuit breaker is another safety feature.

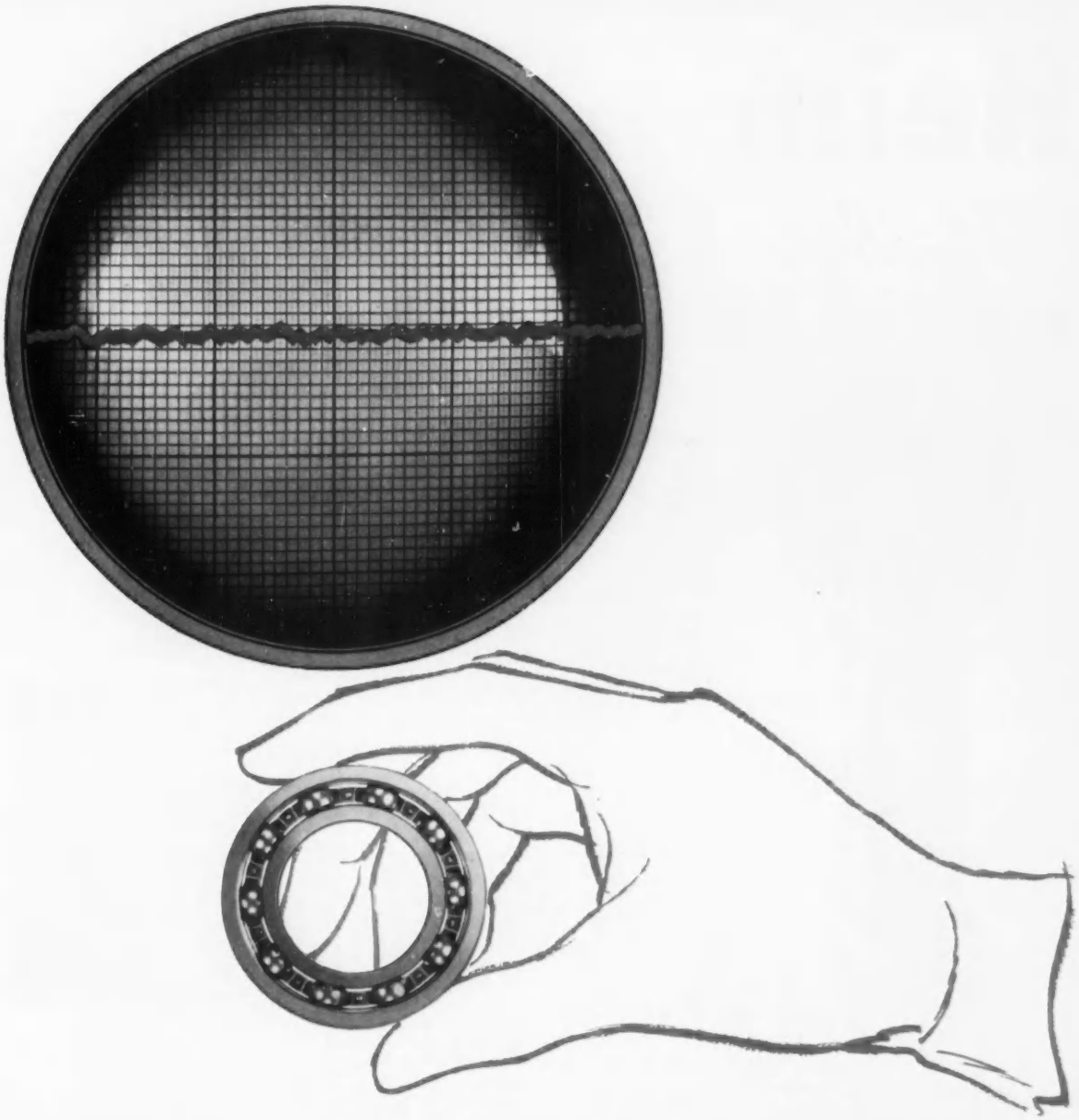
For complete information on reliably safe Westinghouse Press Control with CYPAK, call your Westinghouse Sales Engineer. Or, write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

*Trade-Mark

J-22050



YOU CAN BE SURE...IF IT'S Westinghouse



SCIENTIFIC "SOUNDINGS" PRODUCE QUIET BEARINGS

Through the application of the latest electronic instruments, SKF research engineers have been able to further reduce the sound factor in anti-friction bearings. SKF provides the quietest running, rolling contact bearing in the world of today... at no added cost.

Other recent laboratory achievements include improvements in sealing and increase in bearing operating life, further assuring users the best bearings for their dollar. But accept no substitutes – you benefit from these only when you insist upon SKF. 7763

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EVERY TYPE—EVERY USE

Spherical, Cylindrical, Ball, and Tyson® Tapered Roller Bearings

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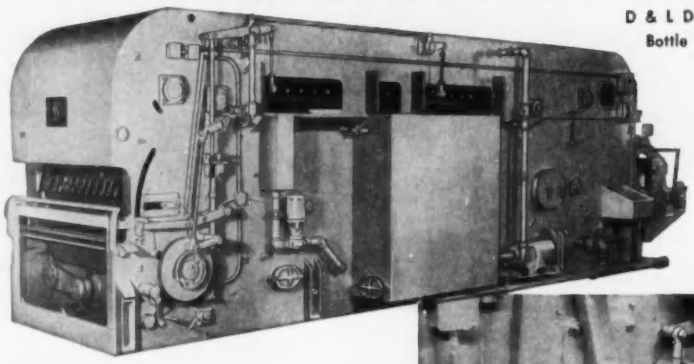
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

Heim *Unibal* Rod Ends

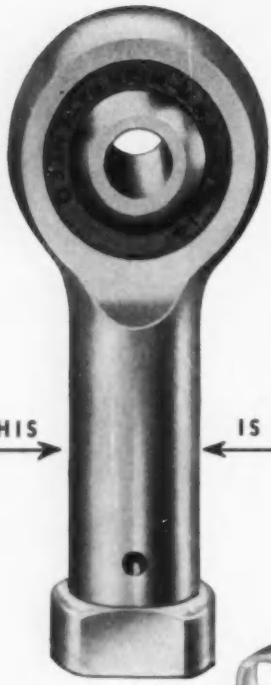
compact . . . easily adjusted . . . bind-free

The Dostal & Lowey Company manufactures automatic bottle washing machines. There is a Single End machine of rugged construction which can be operated by unskilled labor; and there is a Double End washer of great speed and efficiency for high production.

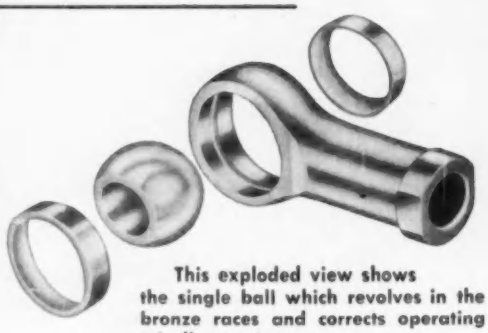
The D & L Single End machine uses 28 and the Double End machine uses 14



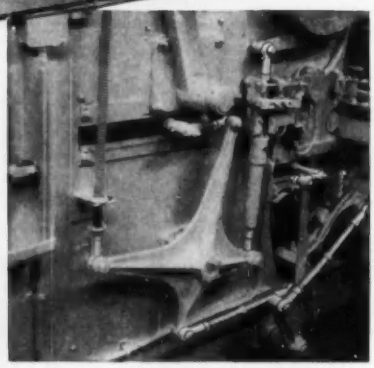
D & L Double End Bottle Washer



THIS → ← IS THE HEIM UNIBAL



This exploded view shows the single ball which revolves in the bronze races and corrects operating misalignments.



D & L Single End Bottle Washer

Have *You* considered the versatile Unibal for your linkages? Heim engineers will help you with suggestions and samples. The leading bearing distributors carry Heim Unibal.

Unibal has many advantages, but those features which led D & L to choose Heim Rod Ends were their compactness, their ease of adjustment after installation, and the fact that they operate with a bind-free smoothness. The minimum maintenance (not a single failure or replacement in six years of use) and self-alignment of Unibal further improves the smooth operation of the D & L Bottle Washers.

The use of Heim Rod Ends in practically all motions of the machines has helped to bring out an important sales point — spare parts inventory is kept to a minimum.

PLEASE WRITE FOR COMPLETE CATALOG

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

HAYNES Investment-Casting Solves the *tough* design problems

INTRICATE DESIGNS Mass-Produced Economically ...by Investment-Casting

Intricate shapes in hard-to-machine metals . . . sound metallurgical structures . . . close as-cast tolerances . . . smooth surfaces . . . are all available on a mass-production basis through HAYNES' investment-casting process. This modern mass-production method enables the design engineer to select the best alloy and most efficient design for an application. Desired parts can be made to specifications economically, regardless of how difficult or costly they might be to produce by other methods.

Haynes Stellite Company's extensive services and experience . . . complete tooling, production, quality control, metallurgical, and finishing facilities . . . plus a staff of more than 200 craftsmen . . . plus a selection of more than 25 alloys . . . guarantees that here you will obtain all the benefits the process has to offer.

For complete details, ask for our 40-page book. Write to HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, Literature Section, 30-20 Thomson Ave., Long Island City, N.Y.

Inspecting Castings—Every casting is carefully inspected to insure top quality. "Zyglo," gamma ray, x-ray, and hundreds of precision gages are available to make sure parts meet specifications.

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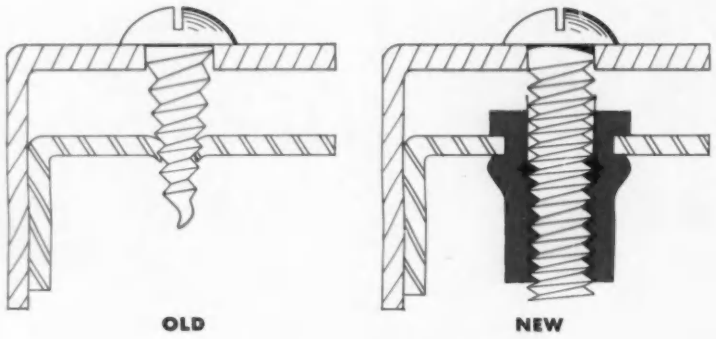
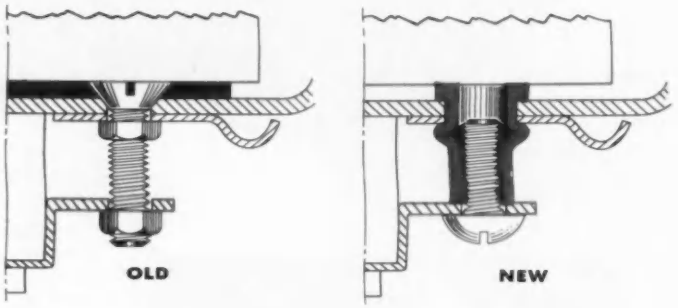
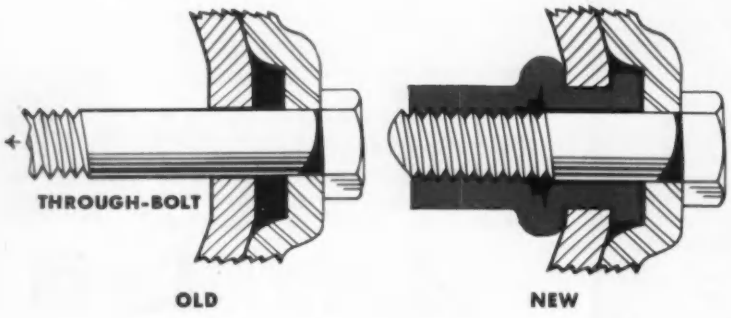
Compare B. F. Goodrich Rivnuts®
with other fastening methods



RIVNUTS ARE STRONGER — Installing retaining clips in aluminum storm doors with ordinary self-tapping screws involved service problems for the manufacturer. Screws enlarged the holes, pulled out, and larger screws had to be substituted by the user. But B.F.Goodrich Rivnuts provided a firm, accurate nutplate that didn't loosen with shock, vibration or repeated use. Six clean threads eliminated any pulling or tearing of metal during assembly or later. The B.F.Goodrich Rivnuts speeded assembly, too, because installation took only a few seconds.

RIVNUTS SAVE MONEY — Assembling vaporizers the old way required a reinforcing plate with two machined countersunk holes for the bolt heads. In addition, the bolts frequently turned and tightened, bending the lower flange out of alignment. Using B.F.Goodrich Rivnuts, the reinforcing plate could be removed and the lower flange held secure without bending. Result—a better product, requiring less assembly time and fewer parts, and a substantial over-all cut in production costs.





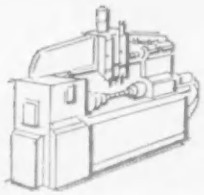
RIVNUTS FASTEN BLIND — Using conventional nuts and bolts it took two men to fasten arm brackets on street lights. Now one worker in the factory installs Rivnuts in the aluminum pole. The assembler merely slips the slotted part of the arm bracket over a bolt in the lower Rivnut, puts the top bolts in place and tightens all three. Assembly costs are lower by 50% because one man now does the work of two. And tests show that the pole or arm bracket will fail before the Rivnut.

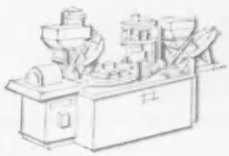
Free Rivnut demonstrator shows with motion how Rivnuts fasten *to* and *with*. To get yours, write: B.F.Goodrich Rivnuts, Department PE-97, Akron, Ohio.

B.F.Goodrich

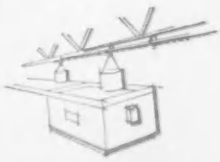
B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

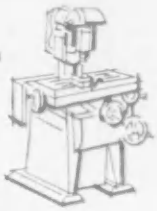


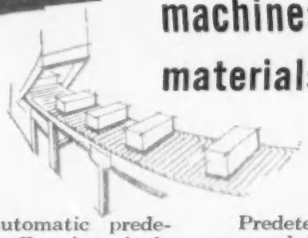


NEW ELECTRIC PREDETERMINING COUNTER...



for remote operation of machines, processes, materials handling





This Veeder-Root automatic predetermining control device offers, in a single unit, new convenience and flexibility in the solution of machine and process control and materials handling problems. Five readily set control knobs provide great ease in establishing any of the 100,000 possible control points. The electromagnetic counting unit permits the use of a wide variety of remote actuators, switches, contactors, electric eyes, or other sensing units. This provision, in conjunction with the several possible electrical control circuits, allows completely remote operation of the controlled equipment.

Predetermining control units can be grouped in a single central location for convenient setting of the predetermined quantities and visual monitoring of the accumulated counts. Additional ease of operation is afforded by the two-second duration electric reset which allows completely automatic recycling, automatic reset in preparation for the following cycle, or push button reset whenever desired. For full details, write:

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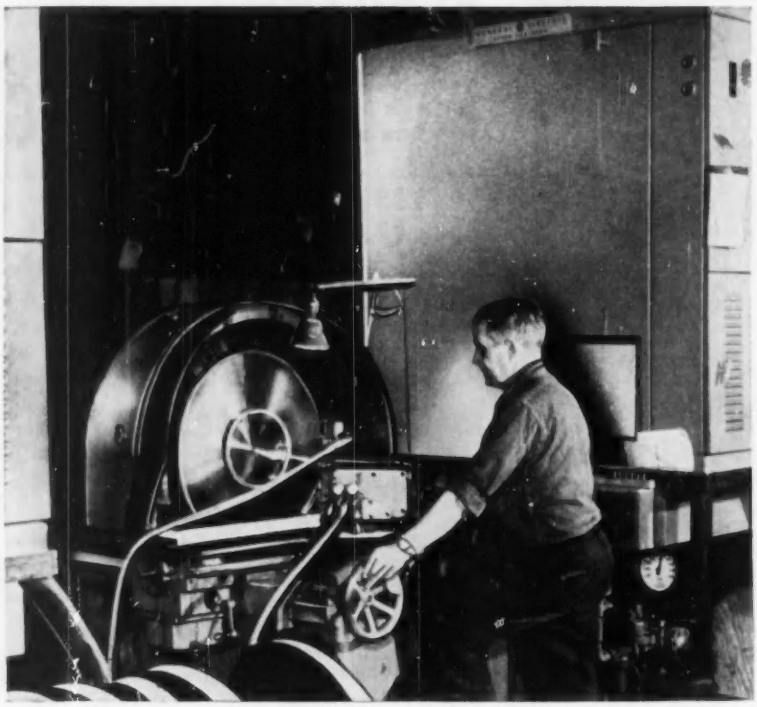
Everyone can count on

VEEDER-ROOT

Designer's

Packaged, easy-to-install Speed Variators give machines you build wide-range adjustable speed



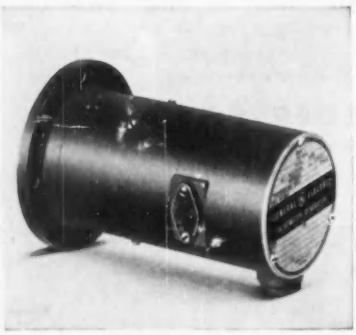
On milling machines, lathes, boring mills, and other machine tools, you can build in improved production continuity and greater versatility of product output with a General Electric packaged Speed Variator. This system-engineered adjustable-speed drive provides closely controlled speeds and a wide range of speed adjustment.

Pre-engineered, assembled, packaged and tested to your specifications before it leaves the factory, this G-E drive features easy, low-cost installation. Just set the components in place—d-c drive motor, space-saving power unit, and operator's control—and connect the load. Power unit and control can be located wherever convenient.

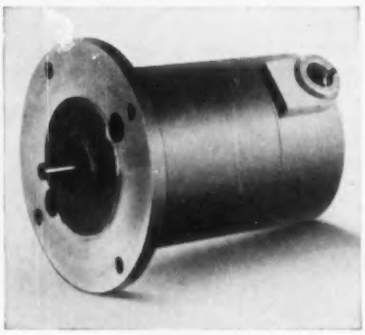
A wide selection of available ratings and speed ranges in the basic unit meets most adjustable-speed needs. To match your particular needs still more closely, other features can be added, including dynamic braking, jogging, reversing, and regulation (amplistat, electronic, or amplidyne). See Bulletin GEA-6127.

◀**CONSTANT CUTTING SPEED** is provided by this General Electric Speed Variator, driving lathe for machining jet turbine wheels.

New small-diameter tachometer generators measure and regulate motor speeds



D-c tachometer generator



A-c tachometer generator

In speed-regulated drive schemes such as those used for automated process machinery, speeds from 100 to 5000 rpm can be accurately measured with General Electric's new d-c tachometer generators, used with suitable instrumentation. These lightweight (less than 6½ lbs) units supply a signal source needed to maintain speed regulation.

Also available are a-c tachometer generators weighing less than 4 lbs. These units, of 4-pole construction, serve speed ranges from 400 to 5000 rpm.

Both units are less than 3½ in. in diameter and totally enclosed. See Bulletin GEC-1405.

GENERAL ELECTRIC

Digest

PRODUCT HIGHLIGHTS

General Electric numerical positioning control systems increase machine-tool productivity and accuracy, cut waste

With General Electric numerical positioning control designed into the machine tools you build, your customer can:

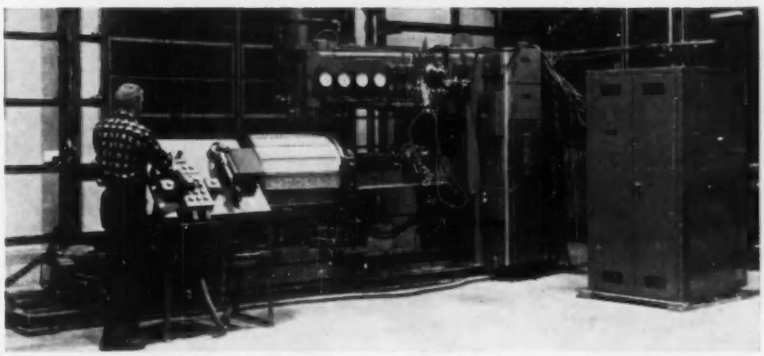
Raise machine productivity by eliminating time-consuming making and setting of templates, allowing more time for productive work;

Raise machine accuracy because NPC can maintain accuracies up to ±.0005 in. automatically, without operator judgement;

Reduce spoilage because NPC automatically directs the machine and removes the factor of human error;

Raise machine speed since NPC can be programmed to utilize optimum machine horsepower feeds and speeds prechosen by engineer.

Easily apply it, where point to point positioning is required, to turret-type punch presses, step turning lathes, shears, riveting, placement, milling, boring, and drilling machines.



FIRST USE OF PRE-PUNCHED TAPE in G-E numerical positioning control is on this resistance welding machine made by National Electric Welding Machines Co. It makes 1650 spot welds on automatically positioned liner of jet engine afterburner for General Electric's Small Aircraft Engine Department. Metal cabinet (r.) houses positioning control.

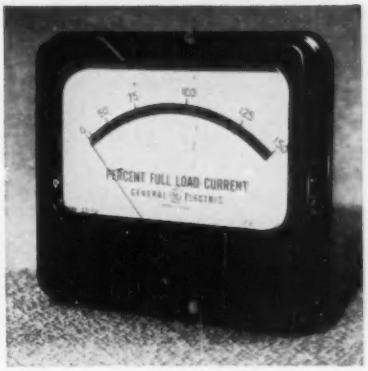
With this method for automatic programming of machine cycles, the operator merely pushes start button and machine automatically runs through sequence of operations required. Speed, accuracy, and length of motion can be individually selected for each application. See Bulletin GEA-6594.

New coolant-pump motor has long bearing life

For long bearing life, this new General Electric fractional-hp motor has large grease reservoirs that hold a supply of a new, moisture-resistant grease that lasts for 10 years of normal motor operation. Specially designed for machine-tool coolant pumps, the motor is totally enclosed to minimize the danger of damage from entrance of metal and dirt particles, provide operating dependability. Unified insulation system permits extra-long motor life. Mounting can be either horizontal or vertical, direct-coupled to your pump. Ratings are ¼ to ¾ hp. See Bulletin GEA-6582.

Machine-tool load indicator applies to any a-c motor

A continuous visual check on **all** a-c motors—in any horsepower, voltage or commercial frequency—is provided by General Electric load indicators. Standardizing on one indicating instrument in your machine-tool designs gives you availability, stocking and price benefits.



Easy-to-read color scale shows safe, caution and danger zones. Indicator is calibrated in per cent of motor full load current; no need to know actual current. Wide variety of sizes includes 4½-in. type with 3-in. scale (shown) 3½-in. type with 2-in. scale, and concentric-scale types in 4½-in. and 8¾-in. sizes. See Bulletin GEC-368.

General Electric Co., Apparatus Sales Division, Section P 668-135, Schenectady 5, N. Y.

Please send me the following bulletins:

✓ for reference purposes	X for immediate project
☐ GEA-6127 Packaged speed variator	☐ GEA-6582 Coolant pump motor
☐ GEA-6594 Numerical positioning control	☐ GEC-1405 Tachometer Generators
☐ GEC-368 Panel Instruments	

Name_____ Company_____

City_____ State_____

Republic

POSITIVE HOLDING-POWER of Republic Nylok Bolts keeps striker plate in precise position to assure proper functioning of safety door-latch. Other advantages of Nylok Bolts include their liquid-sealing ability. When unit is fully seated in tapped hole, nylon pellet blocks escape of fluid around helix of threads.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Nylok® Fasteners Assure Positive Performance

of Safety Door-Latch Design

There is no room for error in safety engineering. Not even in the smallest detail. That's why Ford Engineers use Republic Nylok Bolts to anchor striker plate to door post.

Nylok Bolts permit precise positioning of striker plate to safety latch during assembly. When torqued tight they provide a positive, vibration-proof clamping action to keep the plate locked in place. Holding-power of latch assembly is permanently maintained.

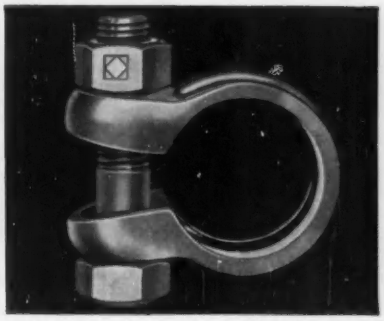
Republic Nylok Bolts have proved ideal for a wide variety of bolted assemblies subject to impact or vibration. Their relentless grip is produced through compression of a small nylon pellet imbedded in the bolt body when unit is wrenched into threaded hole. In attempting to regain its original shape, the pellet exerts a continuous, powerful lateral thrust, forcing a strong metal-to-metal lock between opposite mating threads. Lock is positive, whether or not bolt is seated. Further, this resiliency of nylon provides excellent adjustment and re-usability characteristics, and permits relatively soft materials to be locked to threaded members without damage.

In addition to design advantages, use of Republic Nylok Bolts offers many production savings. They can be hand or power wrenched with equal effectiveness. There is no galling of threads or seating surfaces. Expense of assembling extra locking devices or wiring is eliminated.

Finally, you get all the advantages of Nylok locking plus top fastener quality when you specify Republic Nylok Bolts. Complete manufacturing control from ore to finished product is your assurance of consistent peak performance.

For full information, contact your nearest Republic office. Or mail coupon.

DEPENDABLE PERFORMANCE is built into Republic Chain Slings by careful control of every manufacturing step from raw ore to finished product. Available in single, double, triple, and quadruple types—in carbon and alloy steels and wrought iron. All assemblies, including matched accessories, are proof-tested before shipment. For illustrated Chain Sling Catalog, ADV-719, mail coupon.



REPUBLIC NYLOK NUTS provide safe, simple, strong locking action, using the same nylon pellet principle as Nylok Bolts. They are ideal for automatic feeding because they assemble from either end. A vibration-proof lock is obtained wherever hand or power wrenching stops. Easy adjustment and re-use are assured by permanent resilience of pellet.

POSITIVE MANUFACTURING CONTROL assures quality in components or products, produced to your specifications by Republic's Pressed Steel Division. Facilities include presses capable of forming every gage stamping, up to the heaviest. Also, welding, brazing, riveting, machining, annealing, galvanizing, and painting operations are available. For information on extending your production capacity with Republic Contract Facilities, mail coupon.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-3841
3150 East 45th Street
Cleveland 27, Ohio

Please send me more information on:
☐ Nylok Fasteners. ☐ Contract Facilities.
☐ Please send me Chain Sling Catalog, ADV-719.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT...

Shaft Location Under High Radial Loads with Cylindrical Roller Bearings . . .

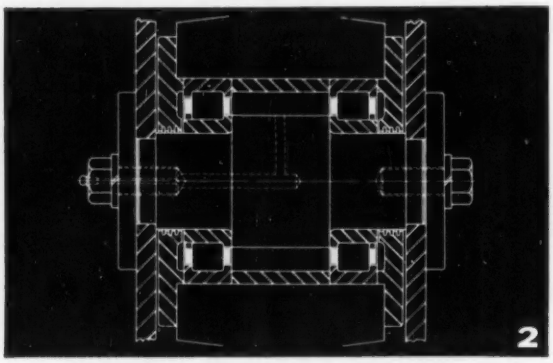
HYATT provides a variety of shouldered-race types to assure dependable shaft restraint in one or both directions . . . plus maximum radial load capacity

Cylindrical roller bearings have long been recognized by design engineers for their unequaled ability to sustain heavy radial loads. Since the primary movement of wheels, shafts or gears with respect to stationary housings in all types of machinery is *rotational*, the basic design of cylindrical roller bearings is relatively simple, and at the same time excellent for: a) Supporting heavy radial loads, and b) Positioning moving parts accurately with respect to their axes.

Less well recognized, however, is the ability of properly-built cylindrical roller bearings to perform most efficiently a third function frequently required of bearings: c) Locating moving parts laterally.

1. CHOICE OF BEARING TYPES

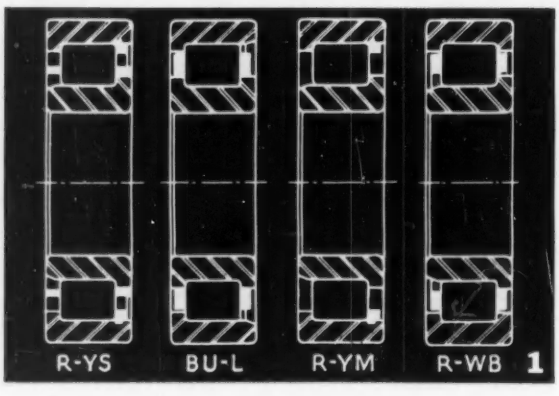
The design may require parts to be restrained laterally in one direction only, or in both directions, and this definitely determines the selection of bearings. Here the designer has a choice of types, depending on whether the machine elements favor one or two shouldered-race bearings. Whether inner or outer races are shouldered or whether assemblies are separable or non-separable has no effect on the ability of the bearing to perform its primary functions of supporting radial loads and positioning parts axially.

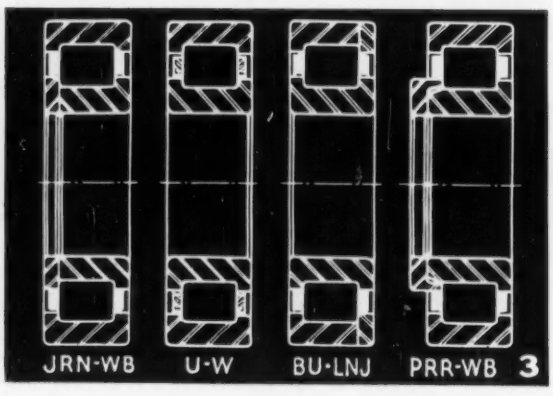


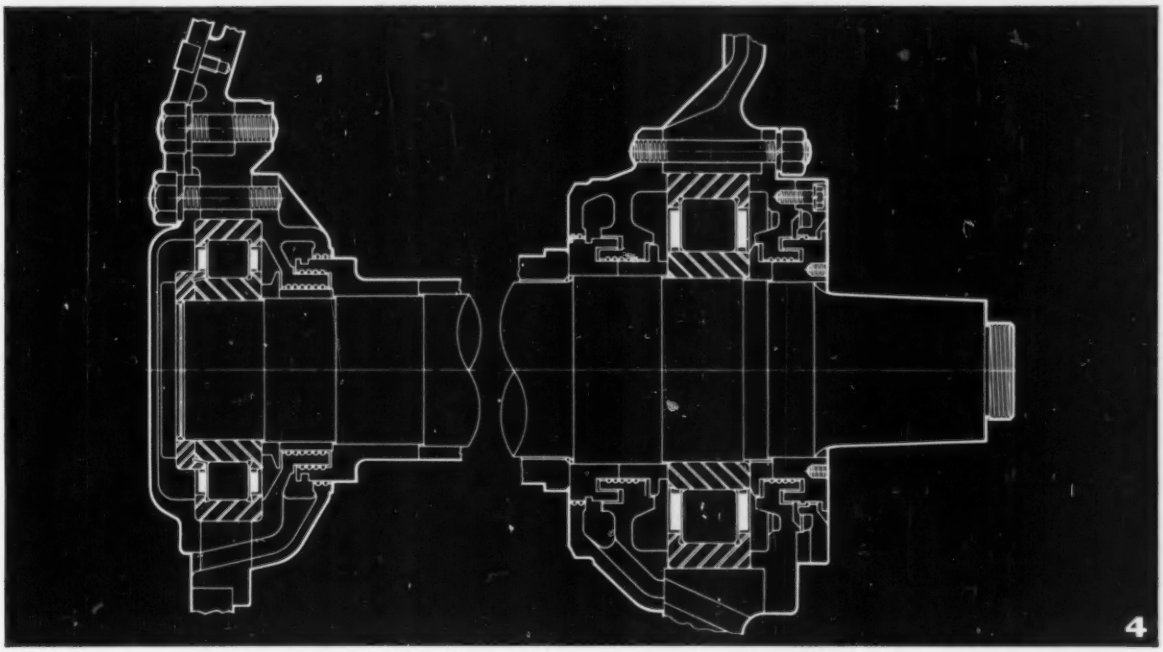
2

2. ONE-DIRECTION LOCATING BEARINGS

In most applications shaft location is accomplished by two opposing shouldered-race bearings, one restraining shaft movement in one direction and the other in the opposite direction. Depending on the conditions present, the designer has a choice of HYATT HY-ROLL types R-YS, BU-L,





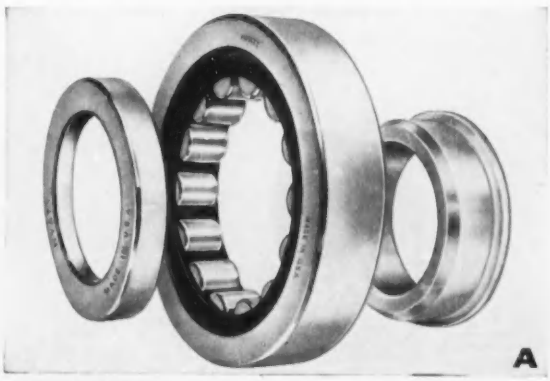


Diesel locomotive traction motor armature shaft with HYATT type PRR-WB at commutator end, type A-WB at pinion end.

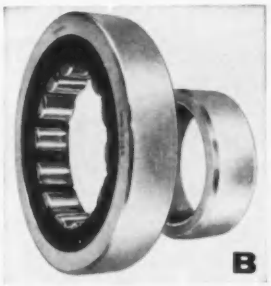
R-YM, R-WB (Fig. 1). Type RW-B, for example, has conclusively proved its shaft-locating dependability in heavy-duty service such as the armature shafts of steel mill motors and elevator cable sheaves. All four types are normally mounted in opposing pairs (Fig. 2). Sufficient end clearance is usually provided in the assembly to prevent binding in operation, particularly if temperature conditions cause the shaft to expand laterally.

3. TWO-DIRECTION LOCATING BEARINGS

Where the application indicates the use of only one bearing to locate a moving part in both directions, the designer may choose from HYATT Hy-Roll types JRN-WB, BU-LNJ and PRR-WB—or for relatively light loads, type U-W (Fig. 3). An outstanding heavy-duty application of type PRR-WB, for instance, is on the commutator end of diesel locomotive traction motor armature shafts. Used in this manner, the commutator end bearing relieves the pinion end bearing of all thrust forces, thus permitting it to function most effectively in supporting the heavy radial loads transmitted by the drive pinion. Type PRR-WB has a long record of excellent performance in this punishing service (Fig. 4 and Photo A).



4. PROVISION FOR SHAFT EXPANSION



Another advantage of using a HYATT bearing capable of locating the shaft in both directions is that it permits the shaft to expand laterally. When a HYATT type A-WB with straight cylindrical inner race, for example, is mounted on the other end of the shaft (Fig. 4 and Photo B), the shaft can expand laterally through it without binding the locating bearing.

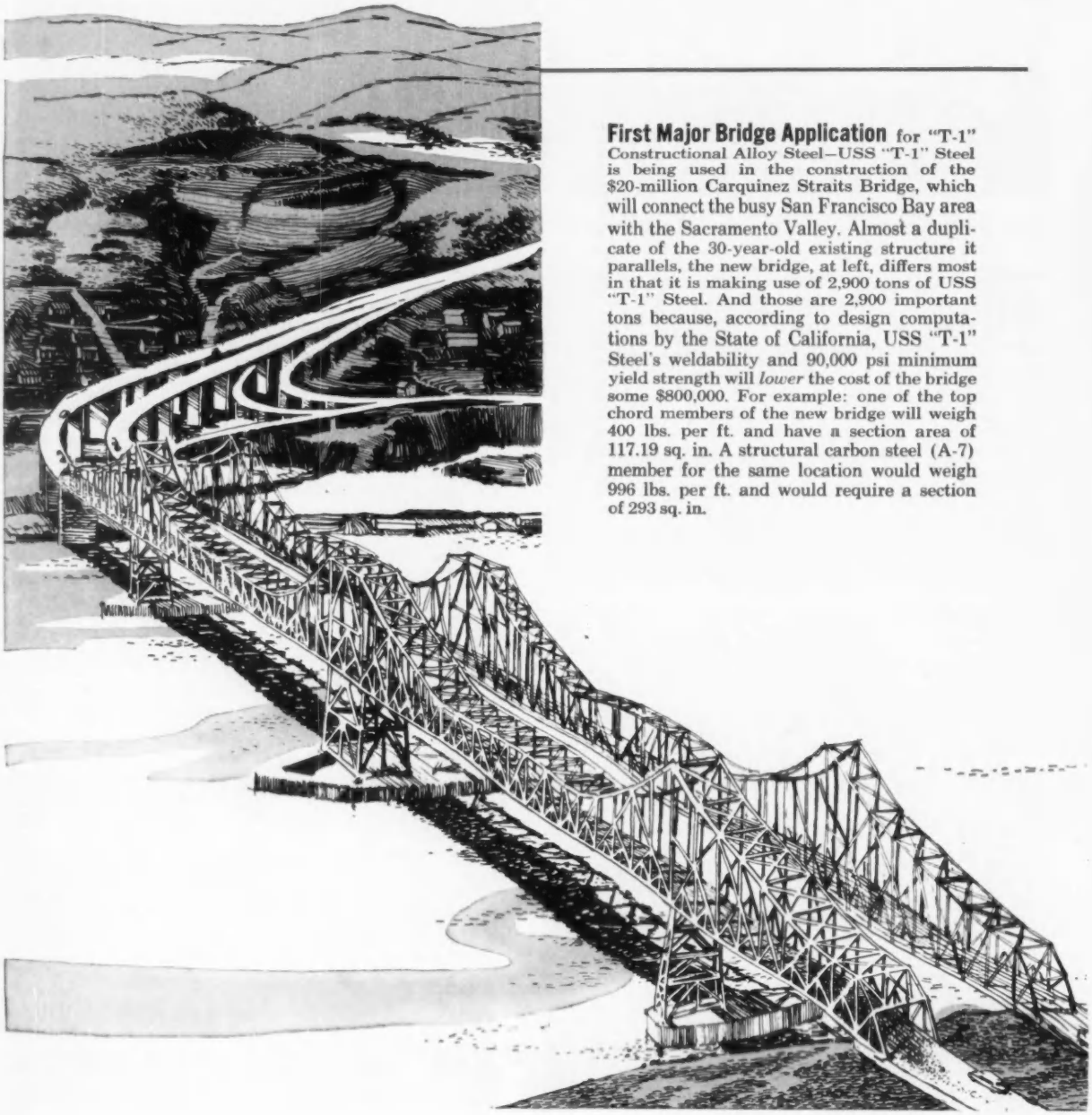
To assure the simplest, most economical and dependable shaft location in one or both directions *without sacrifice of radial load-carrying capacity*, always specify HYATT Hy-Roll Roller Bearings. They will more than measure up to your requirements.

You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer for expert assistance. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; Oakland, California.

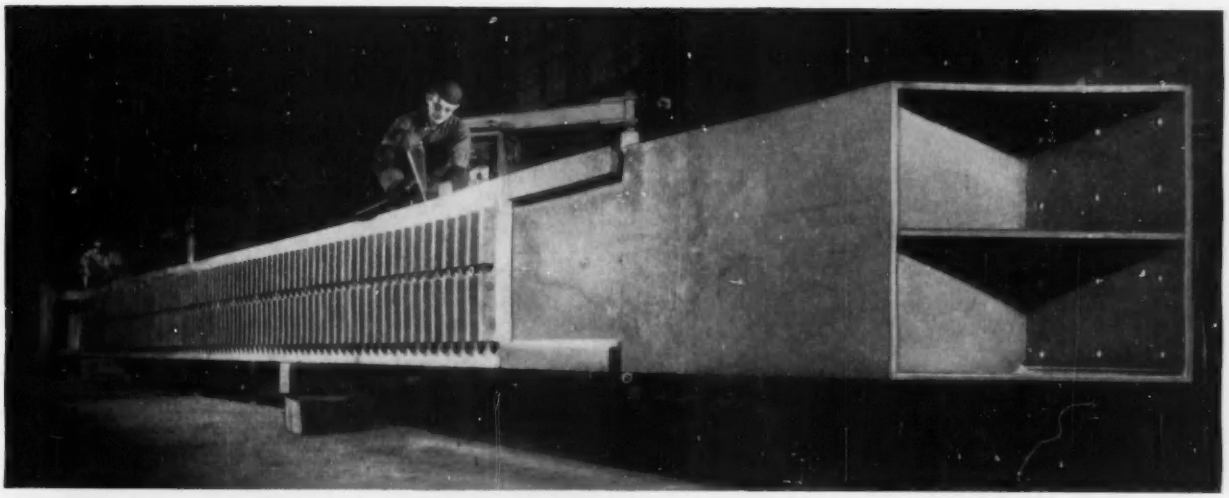
GM GENERAL MOTORS

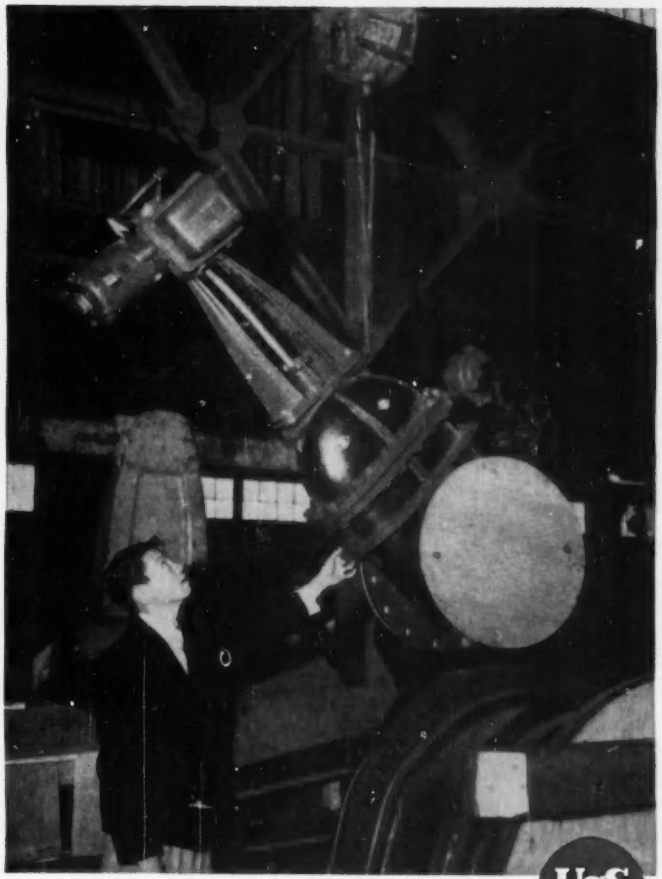
HYATT *HY-ROLL BEARINGS* **FOR MODERN INDUSTRY**

HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS:



First Major Bridge Application for "T-1" Constructional Alloy Steel—USS "T-1" Steel is being used in the construction of the $20-million Carquinez Straits Bridge, which will connect the busy San Francisco Bay area with the Sacramento Valley. Almost a duplicate of the 30-year-old existing structure it parallels, the new bridge, at left, differs most in that it is making use of 2,900 tons of USS "T-1" Steel. And those are 2,900 important tons because, according to design computations by the State of California, USS "T-1" Steel's weldability and 90,000 psi minimum yield strength will *lower* the cost of the bridge some $800,000. For example: one of the top chord members of the new bridge will weigh 400 lbs. per ft. and have a section area of 117.19 sq. in. A structural carbon steel (A-7) member for the same location would weigh 996 lbs. per ft. and would require a section of 293 sq. in.





At Home In A Crowd. That's USS "T-1" Steel. It's really at home in this, the crowd rack of the world's largest power shovel. Built by Marion Power Shovel Company, the big digger is in service for Hanna Coal Company. Operating around the clock, winter included, the crowd rack must withstand constant, brutal impact loading, often in sub-freezing temperatures. USS "T-1" Steel (also used in the dipper, dipper stick and bail) supplies the strength, toughness, and resistance to impact abuse so critically needed.

Fabri-Valve Fabricates Faster For Less. The Fabri-Valve Company of America fabricates valves as opposed to casting them. A recent job for the U.S. Air Force called for 2 types of electric-motor-operated wedge-gate valves, subject to temperatures from well below zero up to 300° F., and pressures of 37.5 psi absolute plus a shock load of 200 psig. By using USS "T-1" Steel for the majority of the valve parts, Fabri-Valve pared off 25% of the time and expense normally required to fabricate the valves. Quoting the Company's Vice President, "USS 'T-1' Steel was chosen for its toughness, impact strength, its quality of handling low temperature applications. Very important, too, is its ready weldability and fabricability. USS 'T-1' Steel's yield strength of 90,000 psi helped reduce thickness, thereby reducing cost."

HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact and abuse at sub-zero temperatures. Its weldability can help you cut the cost of fabricating highly stressed parts, and reduce repair and maintenance expense. Its good creep rupture strength can help you put more durability in equipment that operates at temperatures as high as 900 degrees F.

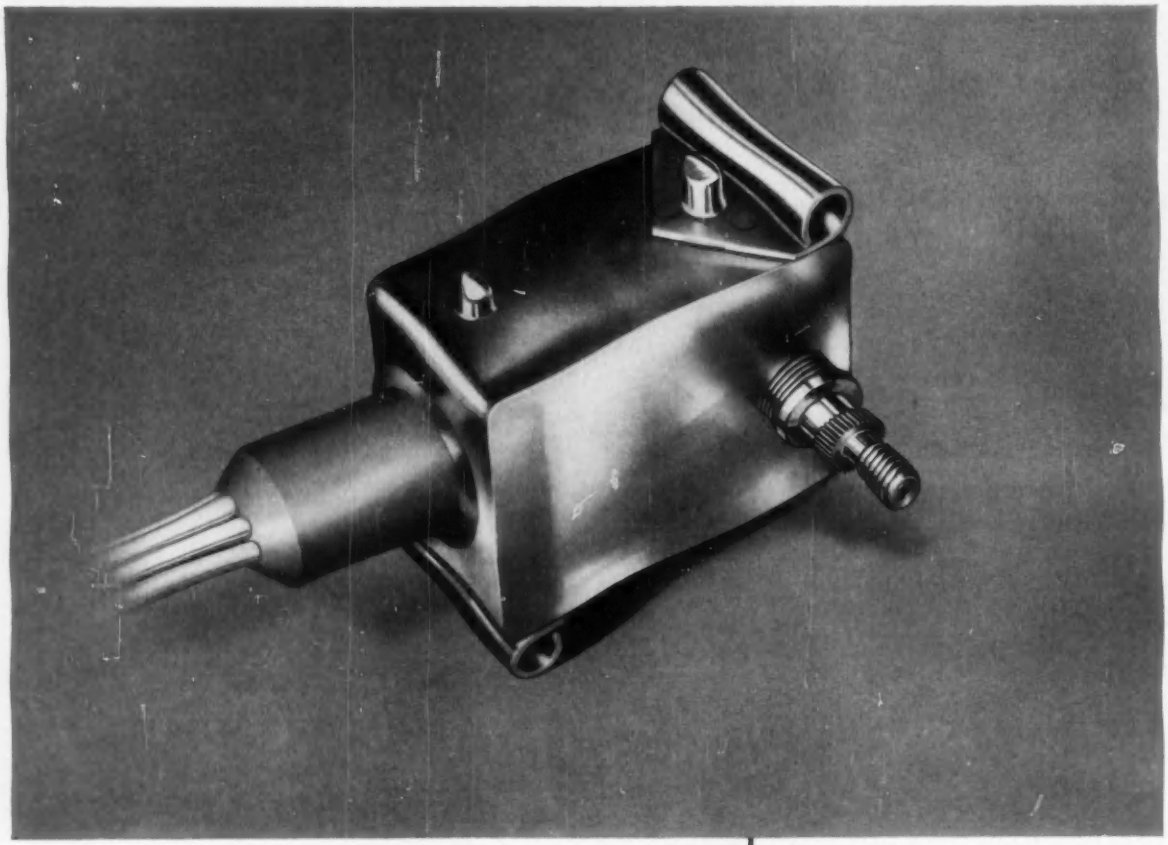
Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Pittsburgh 30, Pa.

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

"USS" and "T-1" are registered trademarks

United States Steel Corporation, Pittsburgh • Columbia-Geneva Steel Division, San Francisco • Tennessee Coal & Iron Division, Fairfield, Ala.
United States Steel Supply Division, Warehouse Distributors, Coast-to-Coast • United States Steel Export Company, New York

UNITED STATES STEEL



NEW
KLIXON C9178
Rotary Hermetic Switch

Gives you environment-free Precision Switching

The new KLIXON C9178 rotary hermetic switch is designed for such precision applications as aircraft landing gear controls, guided missile launchers, radar equipment, engine controls and industrial equipment.

A double-pole, double-throw rotary assembly, the C9178, has two MS24456 Type hermetically sealed switches enclosed in a steel case to withstand heavy impact and compression loads.

The model illustrated has 360° continuous rotation and is designed for positive drive in both clockwise and counter-clockwise directions. Other units are available with limited rotation and/or spring return. All models can be provided with connectors, potted leads and actuator arms designed to your particular specifications.

Technical data sheets on the C9178 and many other types of hermetic and sensitive switches are available. Write for PRSW Catalog.

FEATURES of the C9178 Include:

- **Completely Environment-Free**— basic switches have metal-to-metal, glass-to-metal seals.
- **Simultaneity** — Within 1½° of rotation.
- **Excellent Shock and Vibration Resistance** — shock 50 G's minimum . . . vibration of 40 G's, 0-500 cps, per Procedure I, MIL-E-5272A.
- **High Current Capacity** — 10 amperes resistive, 30 volts DC, 115 volts AC.
- **Minimum Size** — envelope measures 1 29/32″ x 1 15/32″ x 1 1/32″.
- **Immunity of Ambient Temperature** — can be used in ambients from −65°F to +275°F.

METALS & CONTROLS CORPORATION
Spencer Thermostat Division
3809 Forest Street, Attleboro, Mass.
KLIXON®

GENERAL PLATE

Platinum Laboratory Ware

Available with reinforced tops and bottoms

General Plate Platinum Laboratory Ware is available in a wide variety of forms and sizes and, also, with reinforced tops and bottoms for added wear resistance, longer life.

General Plate reinforced laboratory ware retains its shape at the top and is more easily grasped with tongs. It resists cracking and will outlast regular ware under all conditions.

The complete platinum-group metal service available at General Plate includes refining, alloying and fabricating. In addition to manufacturing its complete platinum laboratory ware line, General Plate:

- ▶ Assays and refines platinum-group metals.
- ▶ Recovers and reworks materials previously expended in use.
- ▶ Alloys platinum-group metals.
- ▶ Produces chemical compounds for catalysts and for electroplating solutions.
- ▶ Produces solid and clad metals as sheet — foil — wire — tubing — gauze.
- ▶ Fabricates electrical contacts and contact assemblies for aircraft and automotive magnetos, instruments, controls and other applications; thermocouple wire, and other parts — all to exact customer specifications.

You Can Profit By Using General Plate Clad Metals Write for literature today.

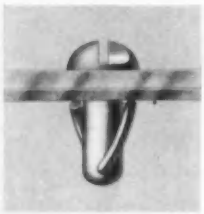
METALS & CONTROLS CORPORATION

General Plate Division

1009 Forest Street, Attleboro, Mass.

How can you use SPRING-LOCK?

THE FASTENER WITH USES UNLIMITED



As a standard removable fastener or a blind rivet

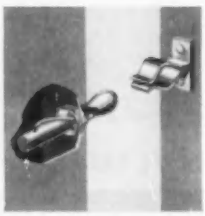
A quarter-turn locks, unlocks. Load-carrying steel arms lock securely, don't loosen under vibration. One-piece (no receptacle) simplifies blind fastening.

As a roller axle

Now used on range drawers, kitchen cabinets, file cabinets, desks. Cuts installation costs, saves time. Designed to suit. Available with or without roller.

As cup hooks

High-strength polystyrene or chrome-plated die cast zinc. Inexpensive, sturdy and good-looking. Simply and quickly installed with a twist of the wrist.



As a cabinet door strike

Millions in use on kitchen cabinets, automatic dishwashers, etc. Standard strikes available from stock, or custom designed for special contour requirements.

As a plastic shelf support

. . . with the heart of steel for extra strength. Millions now used by all major refrigerator manufacturers. Complete flexibility of head design.

What is <u>your</u> application for

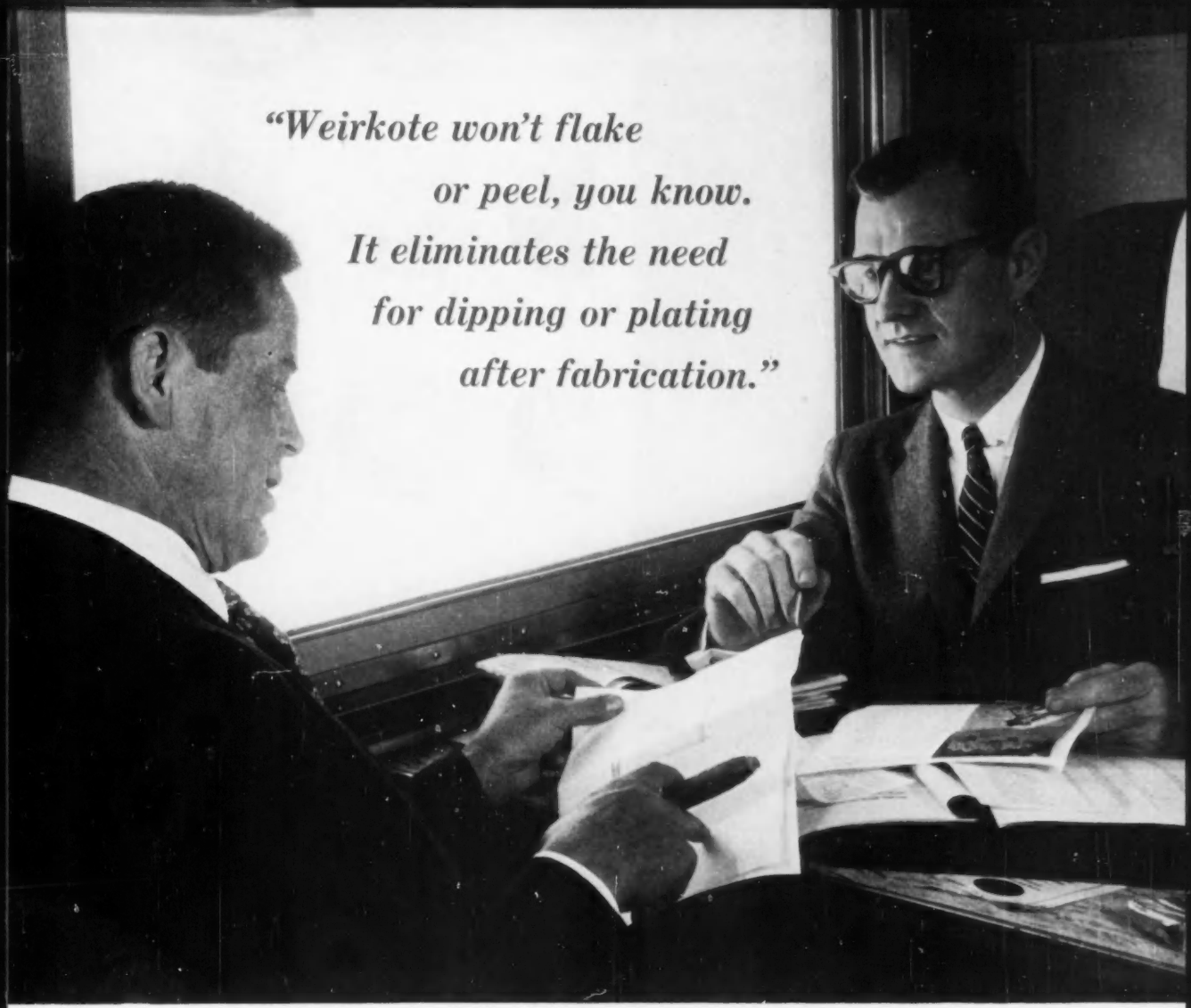
SPRING-LOCK?

Send us your application inquiries. Our engineers will answer you specifically and promptly. Or, write today for the Simmons Catalog. SPRING-LOCK samples are available upon request.

SIMMONS FASTENER CORPORATION

1751 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK LINK-LOCK • DUAL-LOCK



Q.—Weirkote . . . name's familiar. A zinc-coated steel, isn't it?

A.—*Yes, but with a whale of a difference. Weirkote is made by the continuous galvanizing process. Not the old pot-dip way. Its zinc coating is* bonded *skin-tight for keeps. And what an advantage that is!*

Q.—We're using an uncoated steel now, and dipping after fabrication. Even then we have trouble getting a 100 percent coating on some of our more complicated parts. Can Weirkote help us?

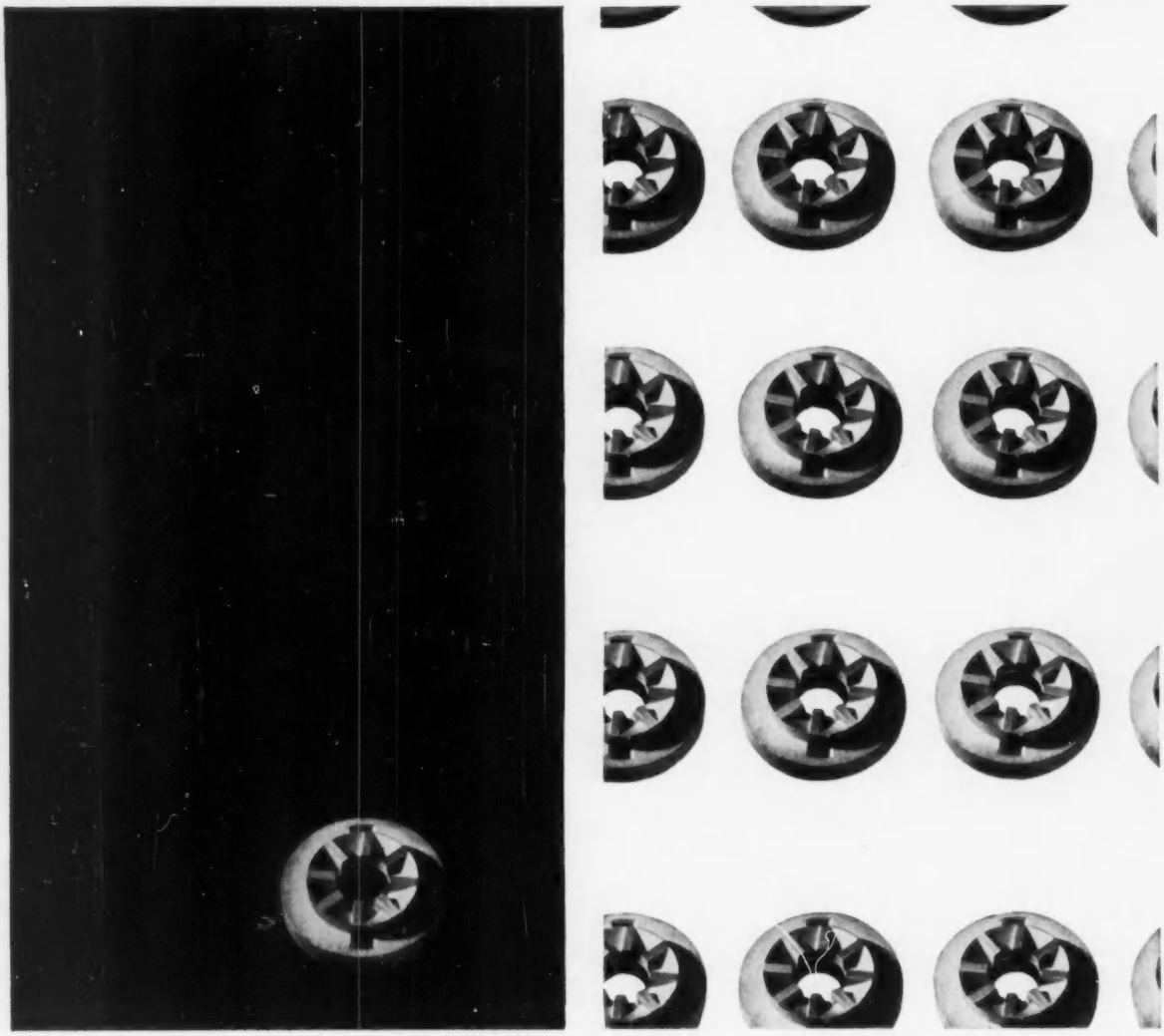
A.—*You bet—Weirkote's zinc coating stands up under the worst fabrication beating you'll want to give it. Shoot the works—stamping, punching, deep drawing, bending, twisting. Weirkote stays put. Stays uniform. Just won't flake or peel.*

Q.—Sounds like Weirkote may be the answer to a lot of our problems.

A.—*Try Weirkote, by all means. You'll never regret it. Weirkote is one of the shortcuts to economy* and *quality in your business and ours.*

Send today for free booklet that details the time- and cost-saving advantages of using skin-tight zinc-coated Weirkote. Write Weirton Steel Company, Dept. D-2, Weirton, West Virginia.

WEIRTON STEEL COMPANY
WEIRTON, WEST VIRGINIA
a division of
NATIONAL STEEL CORPORATION



Does *volume* limit use of metal powder parts?

Yes, it does. For unless volume is sufficient to justify tooling costs, nobody benefits from the metal powder process. But when volume is sufficient, and the design is practical for the metal powder process, savings can be impressive. Even the most complicated part, for example, may be produced in a single press operation. Yet closer-than-ever tolerances are maintained.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio

200° F

500° F

1000° F

2000° F

HEAT RESISTANT...

At aircraft firewalls or in guided missiles... wherever high temperatures are encountered ... you can get full protection by using Cannon Steel Shell High Temperature Connectors to protect electrical circuits.

MS-K receptacle with crimp-type contacts

FW-23 plug, either crimp or solder-pot contacts

FWR-31SL wall mount receptacle, socket insert

FWR-22 plug, pin insert assembly

Cannon Electric supplies both MS-K and FW fireproof types of electrical connectors for the protection of vital circuits in flame barrier applications.

The fireproof test of Military Specification MIL-C-5015 assures that a connector will carry a specified current for 5 minutes and prevent the passage of flame for twenty minutes while being subjected to a flame of 2000°F. Cannon AN-K Connectors meet this specification.

In addition to firewall plugs Cannon Electric has developed connectors that operate continuously up to 1000° F. Developments are under way that will increase the temperature range. We would like to suggest that you will find it well worth your while to consult our engineering personnel for full information on the newest high temperature connectors available.

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

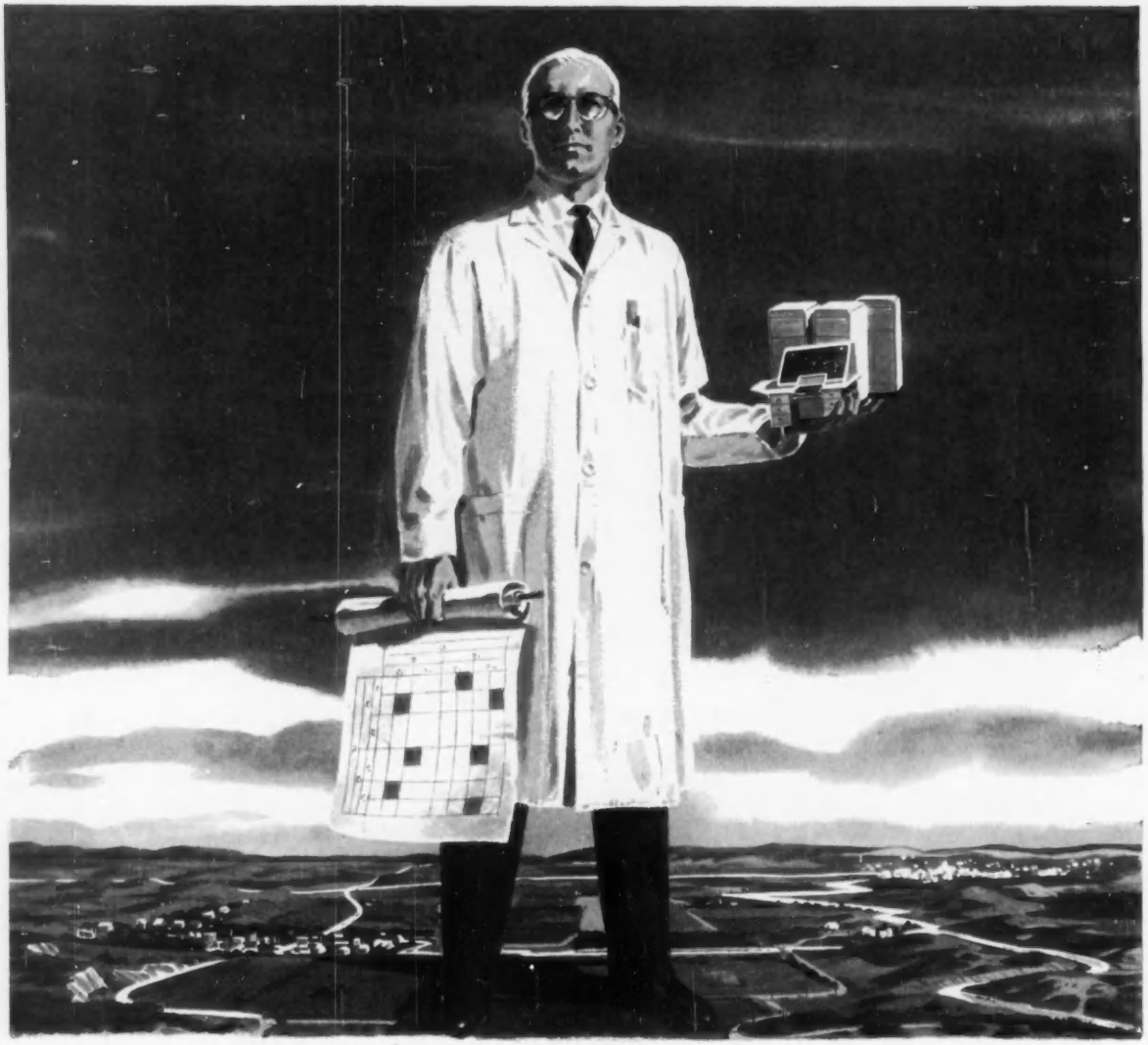
Please refer to Dept. 106

More than 23,000 Cannon Connectors assure you the opportunity of selecting exactly the right connector for any particular application you have in mind. Please write for new 44-page, 2-color Cannon Plug Guide, Bulletin CPG-3.

CANNON PLUGS

WHERE RELIABILITY IS THE 6TH DIMENSION

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, California. Factories in Los Angeles, Salem, Mass., Toronto, Melbourne, London. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities.



Latin Square, Univac and 36 years experience

all three help assure National Seals are best engineered

Univac you know, experience you know; the Latin Square? An ancient, half-forgotten solver of problems having many variables. Today, National Seal engineers use it to reduce exploratory engineering time as much as 75%.

Old, new, time-tested and visionary—National Seal engineers embrace every approach that can help keep National Seals the best engineered in America. Results have been good. Syntech®, the milestone in synthetic rubber seals and Micro-Torc®, major forward step in leather seals, are but two examples.

National Seal's advanced engineering, in plant or field, is ready now to help you solve sealing problems. This help is yours for a telephone call.

VITAL: Whatever seals you buy, save trouble and expense later on by specifying them "on the board." For safety, have specifications checked by a National Seal engineer.

NATIONAL SEAL Division, Federal-Mogul-Bower Bearings, Inc.

General Offices: Redwood City, California; Plants: Van Wert, Ohio, Redwood City and Downey, California

36th Year

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DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 42

New, Stronger Silicone Rubber Now More Readily Available

The toughest and strongest heat-stable silicone rubber ever developed is rapidly becoming more available thanks to new production techniques. Introduced in March, 1957, as Silastic* 916, this new Dow Corning silicone rubber combines mechanical strength and abrasion resistance approaching that of conventional organic rubber with the thermal stability and high dielectric properties characteristic of silicone rubber.

Useful over a temperature span ranging from —130 to over 500 F, Silastic 916 is ideally suited for a wide variety of sealing and gasketing applications previously considered "borderline" for silicone rubber. Known applications where Silastic 916 has proved particularly useful range from oven door gaskets to aircraft door seals — from wire and cable insulation to oxygen mask components.

Typical properties for parts made from Silastic 916 include tensile strength in the range of 1500 psi . . . a 50% increase. Tear strength is approximately 200 ppi . . . an increase of 100%. Elongation is over 500% and hardness is from 50 to 60 on the Shore A scale. Silastic 916 also shows excellent resistance to compression set after prolonged exposure to elevated temperatures. (Cont. Pg. 2)

*T. M. REG. U. S. PAT. OFF.

SILICONE FLUID INCREASES RELIABILITY OF PLANE-TO-PLANE REFUELING SYSTEM

The exceptional thermal stability of Dow Corning silicone fluids helped Flight Refueling Inc., Baltimore, to engineer greater reliability and maximum simplicity into their highly successful, high-altitude refueling system.

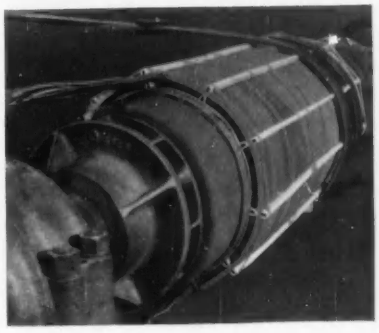
This "probe and drogue" system employs Dow Corning 510 Fluid as the viscous medium in the torque converter used to transfer power from the drive motor to the hose reel. While the hose itself weighs only 300 pounds, it exerts up to 1000 pounds pull due to the high-speed airstream. Another 800-pound pull is required to disconnect the hose when refueling is completed.

Despite heavy loading, a 9½ hp motor is all it takes to pay out hose smoothly at the rate of 5 feet per second, and to retrieve it at twice this speed. That's because the silicone fluid enables the converter to produce maximum torque promptly on demand and keeps the converter serviceable at temperatures down to —65 F. The use of only 5 pints of stable 510 Fluid eliminates the need for mechanical devices to compensate for severe temperature changes.

The "probe and drogue" system is replacing other refueling systems because it's lighter, easier to control, more flexible and can refuel more than one plane at a time. The Navy has standardized on this method for all air-to-air refueling. The Tactical Air Command uses the new system for its KB-50 three-point tankers and for the "Buddy System" where one F-100 refuels another. **No. 426**

New Silicone Insulated Transformers Are Light-Weight, Maintenance Free

Added proof that you get "more power per pound" and maximum reliability with silicone electrical insulation is provided by Moloney Electric Company's new line of 3-phase, nitrogen filled, dry-type transformers.



Take the 1500 KVA rating, for example: these units weigh only 21,000 pounds and measure less than 9½ x 5½ x 10 feet. Silicone-insulated throughout, they can be safely installed almost anywhere regardless of high ambients, contaminated or dust laden atmospheres. In addition, these transformers are virtually maintenance-free; no liquids to maintain, no toxic fumes to guard against.

Contributing to the transformers' efficient performance are the strong, lightweight silicone-glass spacer bars laminated by Formica Company into U-shapes for maximum heat dissipation. Moloney (Cont. Pg. 2)

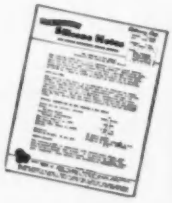
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION®

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



New Reference to Silicone Fluids describes the Dow Corning silicone fluids specified for most industrial and military applications. This convenient four page reference lists typical applications, and physical and electrical properties for each fluid — from flash point to volume resistivity. A useful and compact data source designed to help you select the silicone fluid most suitable for any specific application. *No. 430*

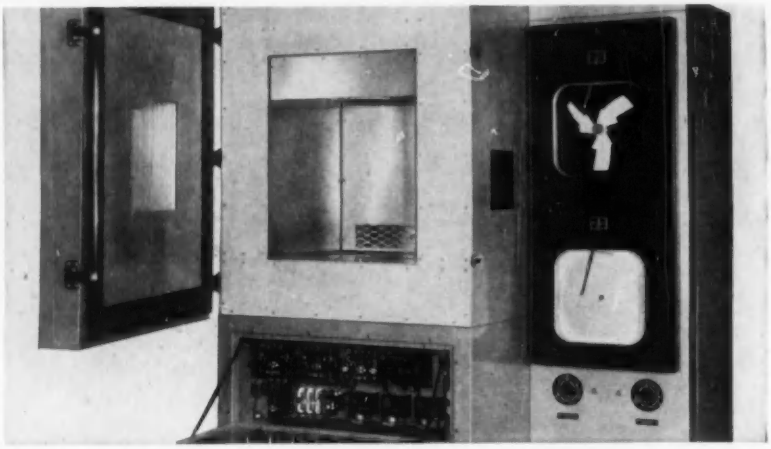
Silicone Rubber That Vulcanizes At Room Temperature — that's new SILASTIC RTV 501. Has good shelf life before catalyzing, longer working time after catalyzing. Two fluid components, mixed together, vulcanize over a period of 24 hours to form a 30 durometer rubber serviceable from —70 to 500 F. *No. 431*

Silicone Insulated Motors Last Longer — Cost Less. A new brochure bears out this fact with numerous case histories of motors operated for years under adverse conditions in many different industries. An illustrated booklet, it's sure to suggest ways in which you can use silicone insulation rewinds to obtain low-cost protection against overloads, high ambient temperatures, rapid reversing, moisture and corrosion. *No. 432*

Silastic, An Ideal Dielectric Material, has high dielectric strength, high thermal conductivity, great resistance to weathering, corona, arcing, ozone, and electrical and mechanical fatigue. And it remains serviceable from —130 to 500 F. A new brochure describes how these properties can help you. *No. 433*

New Flexible Silicone Resin, Dow Corning 808 is used to formulate heat resistant, high gloss decorative finishes for space heaters, incinerators, clothes driers, stoves, and other appliances. Dow Corning 808 Resin shows excellent color retention, gloss retention, and adhesion up to 500 F. For more information, circle *No. 434*

Silicone Bearing Grease, Dow Corning 44, provides long-time lubrication of ball bearings operating from —40 to 400 F. A new brochure includes description of properties and case histories which show that 44 Grease helps cut maintenance costs by lubricating where petroleum greases quickly fail. *No. 435*



Silicone-Glass Laminates Prove Utility In Extreme Temperature Test Chambers

Relatively unaffected by extreme temperatures, silicone-glass laminates have proven ideal as insulating and structural materials in the thermal test chambers produced by Trop-Arctic, Inc. of Muncie, Indiana.

Bonded with Dow Corning silicone resins, the laminated glass terminal strips retain exceptionally high strength and are dimensionally stable at all temperatures encountered during testing. Trop-Arctic's Model STA-FB-4-2-2, shown above, utilizes upwards of 10 square feet of quarter-inch laminate panels. Three 1-inch silicone-glass tubes in the chamber wall protect the thermocouples, interior wiring and fan motor shaft. Silicone-glass laminate is also used to frame the observation window.

Trop-Arctic's thermal test chambers, producing controlled temperatures ranging from —100 to 350 F, are designed for use in the material test laboratories of large aircraft companies. It takes the automatic programmer less than 40 minutes to switch the 4-cubic-foot chamber from one temperature extreme to the other.

According to Trop-Arctic, silicone-glass laminates proved the most practical insulating and structural materials because of their superior "moisture resistance, dimensional stability, tensile and flexural strength, thermal characteristics, chemical resistance, and appearance." *No. 427*

NEW, STRONGER SILICONE RUBBER *(Cont.)*

Silastic 916 is also non-toxic, serviceable at extreme low temperatures and easily processed. It does not "nerve up," but can be milled and compounded after shelf-aging almost indefinitely. Suitable for molding, extruding or calendering, it can be hot-air vulcanized. It has considerably more "green strength" than previous silicone rubbers making fabrication techniques even more similar to those for organic rubbers. *No. 428*

MAINTENANCE-FREE TRANSFORMERS *(Cont.)*

also uses Formica's G-54 silicone-glass for phase barriers and layer insulation.

To complete this all-silicone insulating system, assembled cores and coils are impregnated with Dow Corning 997 Varnish; lead wires are covered with Silastic,* the Dow Corning silicone rubber. *No. 429*

*T. M. REG. U. S. PAT. OFF.

Dow Corning Corporation, Dept. 8621, Midland, Michigan

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DESIGNING WITH ALUMINUM

NO. 25

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

ADVANTAGES OF ALUMINIZED STEEL

ALUMINUM COATINGS on steel provide a means for combatting corrosion and oxidation problems which cost consumers billions of dollars each year. For unless steel is protected by coating, painting or alloying, it deteriorates rapidly in the presence of moisture or high temperatures.

A coating material for protecting steel should have three virtues: long life which means low maintenance, good appearance and usefulness in a variety of environments. Aluminum coatings meet these requirements at low cost.

Favorable Cost Comparison

The cost of aluminized steel is dependent on the cost of the coating metal, the cost of applying the coating and the price of steel. If aluminized steel is compared to zinc-coated (galvanized) steel and the price of steel is assumed to be the same for either coating, then the fact that aluminum is only about one-third as dense as zinc makes the cost of aluminum less than that of zinc for equal thicknesses of coating.

This favorable material cost for aluminum may be somewhat decreased by slightly higher costs of applying aluminum to steel, although fixing the production costs is difficult. Much depends on the process used and the experience of the operator. In general, aluminizing and galvanizing by hot-dipping, which is the most economical process, are comparable and competitive in cost.

Unique Advantages of Aluminum

Aluminum coatings offer advantages in performance and sales appeal in a wide field of applications. On steel they impart the inherent corrosion resistance of aluminum to the steel surface. When suitably treated, aluminized steels are resistant to oxidation at temperatures up to 1800°F.

Aluminum gains its resistance to corrosion at lower temperatures from a thin, colorless layer of oxide which forms rapidly on its surface. Even if the oxide surface layer is scratched, "self-healing" occurs through rapid reoxidation of the affected area.

In very corrosive environments, the aluminum may be attacked slightly, but the attack soon stops because of the protection given by the corrosion products themselves. Zinc, on the other hand, forms corrosion products which are soluble in water, particularly in sulfurous industrial atmospheres. Hence, the protection is gradually lost by dissolution of zinc and through galvanic action as zinc is anodically sacrificed for iron.

Aluminum coatings are also anodic to steel in the presence of electrolytes. However, their electrochemical reaction rates under these conditions are not as rapid as the reactions of zinc.

Occasionally, a slight discoloration may occur at sheared edges and discontinuities in the coating on aluminized steel, but the attack is not progressive and soon halts. In many cases the rust stains will later vanish. Table I shows the results of some recent atmospheric corrosion tests on aluminized and galvanized steels.

Excellent Heat Resistance

The heat resistance of aluminized steel has been known for years. When steel contains aluminum in amount exceeding about 9%, the alloy becomes extremely resistant to scaling at high temperatures. If an aluminum coating is diffused into the steel at 1500-1700°F, the surface of the steel is sufficiently alloyed to prevent oxidation. These coatings are known as "calorized" coatings.

Table II summarized the performance of aluminized steel and mild steel at a temperature of 1300°F. At temperatures up to 900°F, well above the melting point of zinc, aluminized coatings will not discolor in normal use.

CORROSION RESISTANCE OF HOT DIP ALUMINUM COATED AND ZINC COATED STEELS IN NATURAL ENVIRONMENTS

Atmospheres	Product	Period of Exposure	Comparative Appearance
(Severe marine)	Flat Sheet	4½ years	Aluminized steel surface remains relatively bright. Surface of galvanized steel is dull gray. Rust on both materials observed at sheared edges only.
(Severe marine)	Core wire in #4 AWG 6/1 ACSR	4 years	Aluminized steel core wire better than Grade C heavy zinc coated steel wire and markedly superior to Grade A standard zinc coated steel core wire.
(Severe marine)	Poleline Hardware (cross arm braces, insulator pins and racks, threaded ware)	1 year	Aluminized steel hardware excellent condition, surface bright with only slight tarnish. Galvanized steel hardware covered with heavy white deposits and numerous rust spots.
(Severe industrial)	Flat Sheet	1 year	Aluminized steel dark gray with traces of rust at sheared edges only. Galvanized steel covered with rust over more than 50% of surface.
(Industrial)	Flat Sheet	2½ years	Aluminized steel and galvanized steel comparable in appearance. Surfaces dulled with soil deposits. Traces of rust at sheared edges.
(Urban)	Flat Sheet	4 years	Aluminized steel and galvanized steel comparable in appearance. Surfaces dulled gray with soot and dirt deposits. Traces of rust at sheared edges.
	Fence Wire & Barbed Wire	2 years	Aluminized steel remains brighter than galvanized steel. Rust traces at sheared ends of wire where steel exposed.

TABLE I

The heat reflectivity of aluminized steel is excellent. At temperatures up to 900°F, about 80% of the radiant heat

RESULTS OF OXIDATION TESTS AT 1300°F

MATERIAL	Increase in weight in mg./cm² at 1300°F after: 100 HRS.	1000 HRS.
Mild Steel	40.4	147.7
Aluminum Coatings		
Sprayed and heat treated	0.96	3.37
Sprayed, no heat treatment	6.68	13.8
Hot dipped	0.73	2.2
Comm. Aluminum	0.80	3.81
Hot dip 2.65% Si Alloy	1.2	6.2

TABLE II

CONTINUED ON NEXT PAGE ➡

is reflected by the aluminum coating. By lightly rolling aluminized sheet or strip, the surface attains the appearance of rolled aluminum with resulting high reflectivity.

Since aluminum is an excellent conductor of heat, the thermal conductivity of aluminized steel is considerably better than that of uncoated steel and alloy steel.

Wide Range of Applications

Aluminized steel can be welded and brazed, drawn and formed, painted and porcelain enameled. It can also be soldered by special techniques. This versatility of aluminized steel makes it attractive for many applications.

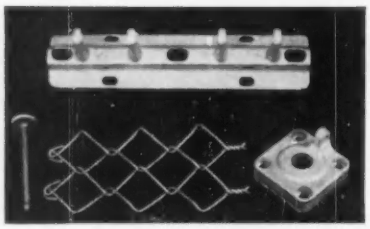

FIGURE 1 Examples of Aluminized Steel Products

A few of the products made of aluminized steel are shown here. Included are a steel forging, cast iron part, fence wire, and an automotive valve on which the head and seat only were aluminized. This valve is an excellent example of how the heat resistance of aluminized coatings can be used effectively. Sheet products are also available and are used in outdoor barbecues, dry kiln fan walls and doors, oil and gas floor-furnace combustion chambers and casings, baking pans, automotive mufflers, and many other applications.

A potentially large consumer of aluminized steel is the electrical transmission and distribution industry where aluminized pole line hardware, telephone wire, and ACSR core wire offer substantial advantages.

For example, in a test involving a severe marine environment, aluminized steel pole line hardware showed no sign of failure after ten months exposure while zinc-coated counterparts were virtually covered with rust.

It is difficult to express the "life" of aluminized steel in terms of the life of galvanized steel, because test samples have not yet failed even though similar zinc-coated items have been destroyed by corrosion in the same environment and in the same exposure period.

Aluminized steel has the pleasing appearance of aluminum but its strength-weight ratio is lower than that of the solid aluminum alloys.

Selection of Coating Alloy

An aluminum coating alloy should be selected with a view to the application of the product. After years of study, Kaiser Aluminum's Department of Metallurgical Research has developed aluminizing alloys with excellent appearance, corrosion resistance, ductility.*

The addition of certain elements alters the melting and solidification characteristics of aluminum coatings and inhibits the diffusion between iron and molten aluminum. This results in smooth surface textures, bright luster and good bending properties. The functions of some of the alloying elements are shown in Table III.

FUNCTIONS OF ALLOYING ELEMENTS IN ALUMINIZED COATINGS[1]

Silicon	— inhibits diffusion between iron and aluminum, thus increasing coating ductility; increases bath fluidity.
Iron, Chromium, Titanium, Boron, Zinc, Beryllium	— improve appearance by increasing coating luster, producing silvery color and smooth surface texture.
Sodium	— increases bath wettability.

[1]All of the alloying elements are not necessarily used in a single coating alloy.

TABLE III

The alloying elements cannot be added indiscriminately. For example, the iron-aluminum alloy layer shown in Figures 2 and 3 should be as thin as possible for the best ductility, less than 0.0004" thick in coatings of 0.001" total thickness. Silicon, by inhibiting the diffusion between iron and aluminum, prevents excessive growth of the brittle iron-aluminum layer. However, coating alloys containing more than 3% silicon darken rapidly and although their corrosion resistance is excellent, they develop an inferior appearance.

*As covered by patent rights of Kaiser Aluminum & Chemical Corporation.

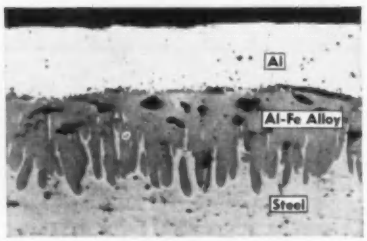

FIGURE 2 500X
Microstructure of Non-ductile Aluminized Coating Obtained with Commercially Pure Aluminum Coating Alloy.

FIGURE 3 500X
Microstructure of Ductile Aluminized Coating Obtained with Kaiser Aluminum Coating Alloy Containing Silicon and Other Alloying Elements.

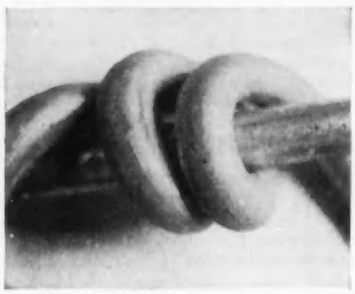

FIGURE 4 3X
Wrap Test on Aluminized Wire with Ductile Coating.

Excessive amounts of iron, chromium, titanium and boron produce rough surface textures, which may adversely affect coating ductility as well as appearance. Thus, a careful balance of alloying element concentration is necessary to obtain optimum properties.

Future of Aluminized Steel

Aluminized steel products are appearing on the market in increasing numbers and applications. The superior performance, appearance, and adaptability of aluminized coatings in various environments are leading progressive designers and sales conscious manufacturers to make use of these advantages.

For information and assistance concerning aluminizing alloys and processes, contact the Kaiser Aluminum sales office or distributor listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11.

see our catalog in
PRODUCT DESIGN FILE
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Kaiser Aluminum
THE BRIGHT STAR OF METALS

NEWS **ANNOUNCEMENT** NEWS

REVOLUTIONARY NEW FASTENER SEAL NOW AVAILABLE

Designers and Engineers Welcome New Vibration-Resistant, Water-tight Fastener

PARKER-KALON® NYLTITE® STAPS® prevent leaks, squeaks, crazing and electrolysis

Clifton, New Jersey—PARKER-KALON, originators of the famous Self-tapping Screw, announced today the availability of a revolutionary, new fastener seal known as NYLTITE STAPS. Consisting of a unique, self-conforming nylon washer preassembled to a standard P-K Self-tapping Screw, the Nyltite Staps meet the needs of designers and engineers for a quick, secure and economical fastener which eliminate hand-assembly of fastener and provide a com-er-and-air-proof seal. As tightened, the nylon s against the shaft of inequalities of the surface and even nterstices. Highly as to humidity, effective seal-ors, freezers, nditioners and ualities of the urface and even nterstices. Highly ell as to humidity, s an effective seal-igerators, freezers, s, air-conditioners and liance products.

MADE OF DUPONT ZYTEL NYLON

The remarkable chemical resistance of Nylon (made of DuPont Zytel) which is used in Nyltite Staps permits the use of Staps for many ap... are subjected ... variet... so... most organic acids. Nylon is not affected by petroleum oils or grease at temperatures ranging up to as high as 250°. ... Staps can be used ... ther con-

NOW!

from PARKER-KALON originators of the Self-tapping Screw

PRE-ASSEMBLED NYLTITE STAPS

for fast, secure, economical, leak-proof fastenings!

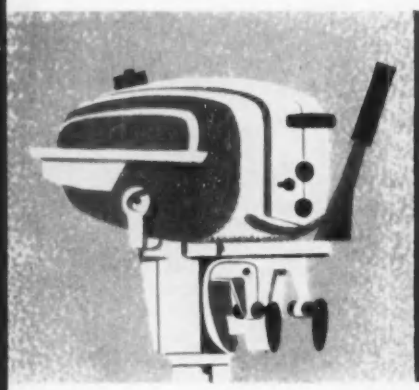
p... tappi...

FOR COMPLETE DETAILS SEE INSIDE

PROTECT PORCELAIN SURFACES . . . REDUCE NOISE END MOISTURE SEEPAGE, ELECTROLYSIS AND

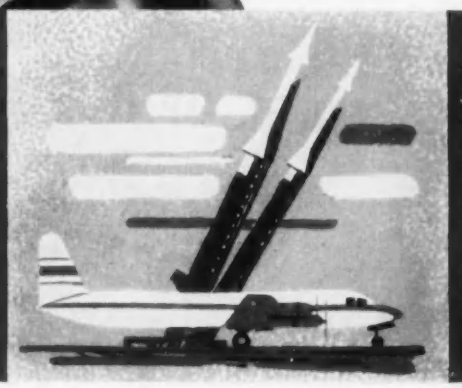
PARKER-KALON® NYLTITE® STAPS®

IDEAL FASTENER-SEAL FOR HOUSEHOLD AND INDUSTRIAL APPLIANCES, OFFICE MACHINES, AUTOMOTIVE BODIES, AIR-CONDITIONING EQUIPMENT. SHOCK-PROOF, WATER-PROOF, WEATHER-PROOF!



UNDER EVEN THE MOST RUGGED outdoor conditions—summer or winter—Nyltite Staps provide a water-tight seal. In assemblies subject to expansion and contraction due to atmospheric conditions, the resilient nylon washer maintains the seal.

MOTOR VIBRATION, high humidity, rough usage—Parker-Kalon Nyltite Staps take them all, cushioning shocks, preventing moisture or oil penetration. Electrolysis is effectively retarded, even in salty or smoke-laden atmospheres.



WHEREVER VIBRATION is a factor, the cushioning effect of the nylon washer, dampens vibration and reduces noise. These are important considerations in the design of commercial aircraft where passenger comfort is essential.

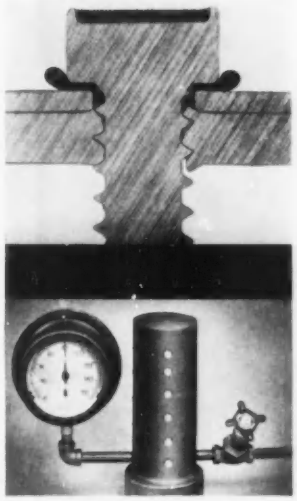
PRODUCTION SAVINGS—BETTER PRODUCTS—with PARKER-KALON Nyltite Staps

Nyltite's nylon washer is preassembled to standard Parker-Kalon Self-tapping Screws and will not come off even with rough or high-speed handling. No hand-assembly of washer to fastener is required. The washer fits snugly against the head of the screw and does not extend beyond the head periphery. There is no color matching problem with P-K Nyltite Staps because the nylon washer is translucent. This is an obvious advantage in making fastenings to assemblies where delicate colors must be considered. The extra cushioning effect obtained through Nyltite's unique folded-upon-itself construction safeguards highly finished or vitreous enamelled surfaces, preventing chipping or crazing and thus reducing rejects or salvage operations. As an insulator, P-K Nyltite Staps

. . . CUSHION VIBRATION . . .

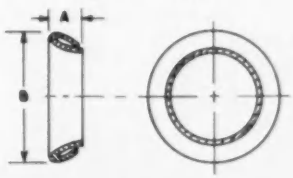
WASHER HAND-ASSEMBLY . . . WITH

Parker-Kalon Nyltite Staps consist of unique, self-conforming nylon washers, preassembled to standard P-K Self-tapping Screws. The specially designed washer is folded upon itself so that the edges appear only on its inner circumference—the fold comprising the outer rim. When the fastener is tightened, subjecting the washer to pressure, the flow of nylon is concentrated to its edges—which exist only at its center. Thus, the shank of the fastener is actually hugged by the "controlled flow" as is shown in the unretouched photomicrograph at the right. In this enlarged cross-section you can observe how the nylon flowed into the thread interstices. Note also the even cushion which insulates the head of the screw from the engagement material. Here is a seal that is perfect.



Pressure Tests—this test was devised to determine the security of a seal under pressure. A number of Nyltite Staps were driven into an air-tight cylinder and tightened to approximately 40"#. The cylinder was immersed in water and 80 to 100 pounds of air was forced into the cylinder. Although the cylinder was periodically checked for weeks, the pressure was maintained and no leaks occurred.

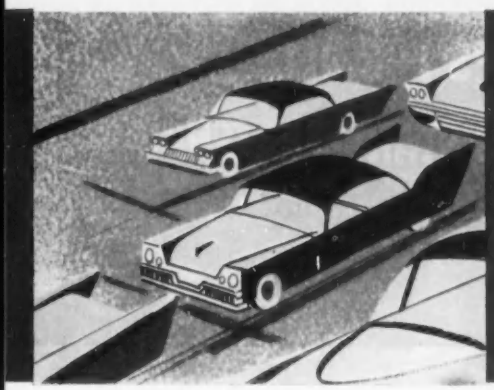
STYLE #100



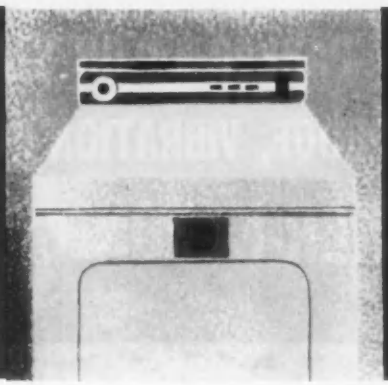
Screw Size	*Nyltite Washer Dimensions		Washer number —Please SPECIFY when ordering
	A Thickness	B O.D.	
6	.093	.230	106
8	.110	.269	108
10	.118	.300	110
12	.118	.325	112
14 - ¼	.118	.355	114

**all dimensions subject to manufacturer's tolerances*

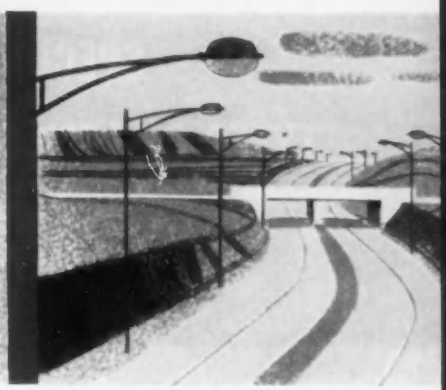
P-K Nyltite Staps are available in production quantities with any style of head, self-tapping screw type or screw size or diameter (with certain limitations). Details upon request.



BODY SQUEAKS, chatter, vibration, moisture seepage—where these are problems in body construction or accessory attachment, Parker-Kalon Nyltite Staps may be an ideal solution. Recommended, too, in boat building and railroad car applications.



IN HOUSEHOLD appliances, washers, dryers, refrigerators, water heaters, etc., Nyltite Staps prevent leakage, dampen vibration and prevent chipping or crazing of highly finished surfaces.



PERFECT SAFEGUARD for electrical lighting fixtures or appliances used out of doors. Nyltite Staps are leak-proof, weather-proof. Winter or Summer, in rain or snow, Parker-Kalon Nyltite Staps provide a dependable seal.

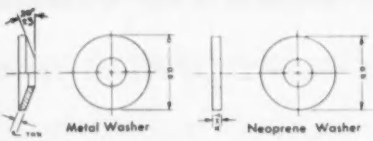
prevent the contact of dissimilar metals, retard electrolytic deterioration. P-K Nyltite Staps meet the requirements of your design wherever a quick, secure, economical water-and-air-proof seal is needed.

PROPERTIES OF NYLON (DUPONT ZYTEL)

The remarkable chemical resistance of Nylon (made of DuPont Zytel) which is used in Nyltite Staps permits the use of Staps for many applications that are subjected or exposed to a wide variety of common solvents, alkali solutions, dilute mineral acids and most organic acids. Nylon is not affected by petroleum oils or greases at temperatures ranging up to as high as 250°. Thus, P-K Nyltite Staps can be used as fastenings in drums or other containers carrying a wide variety of chemicals or petroleum products.

STYLE 200 STAPS—

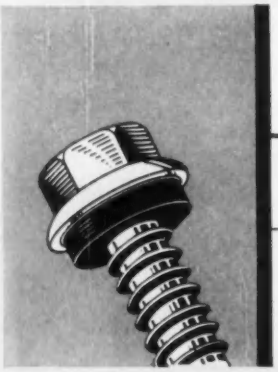
Consists of separate dished metal washer and extruded neoprene washer. Dished metal washer, made of heavy gage steel, has outside and inside diameter slightly larger than unbonded neoprene which permits it to "flow" freely for uniform nesting and lasting seal. As both washers remain concentric under pressure, neoprene "flow" is controlled. Danger of splitting or twisting is eliminated.

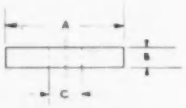


Screw Size	*Metal Washer Dimensions		*Neoprene Washer Dimensions	
	O.D.	Gage	O.D.	Thickness
6	1/2"	20	7/16"	1/16"
8	1/2"	20	7/16"	1/16"
10	1/2"	20	7/16"	1/16"
12	1/2"	18	7/16"	1/16"
14 - ¼	5/8"	18	9/16"	1/16"

STYLE 300 STAPS—

Consists of cut-tube neoprene washer preassembled to a P-K screw having a cupped washer as an integral part of head. Cupped washer holds neoprene captive, preventing spreading under pressure. This concentric control of neoprene makes a lasting, leakproof seal. Liberal thickness of neoprene, cut to uniform dimensional accuracy, has great resiliency and long life.





Screw Size	*Neoprene Washer Dimensions			Washer number —Please SPECIFY when ordering
	A O.D.	B Thickness	C I.D.	
6	.263	.042	.129	306
8	.314	.062	.156	308
10	.365	.093	.171	310
12	.415	.093	.201	312
14 - ¼	.475	.093	.230	314

**all dimensions subject to manufacturer's tolerances*

SPECIFY PARKER-KALON STAPS FOR ALL TYPES OF LEAK-PROOF, VIBRATION-RESISTANT FASTENINGS

PARKER-KALON® fasteners

MAIL THIS COUPON FOR YOUR FREE SAMPLE OF PARKER-KALON STAPS

Parker-Kalon Division
General American Transportation Corporation
Clifton, New Jersey

☐ Please send samples of the new P-K STAPS, technical data and application information.
☐ Nyltite Style 100 ☐ Style 200 ☐ Style 300

☐ Also have a Parker-Kalon Fastener Engineer call to discuss our fastening problems. I understand there is no obligation.

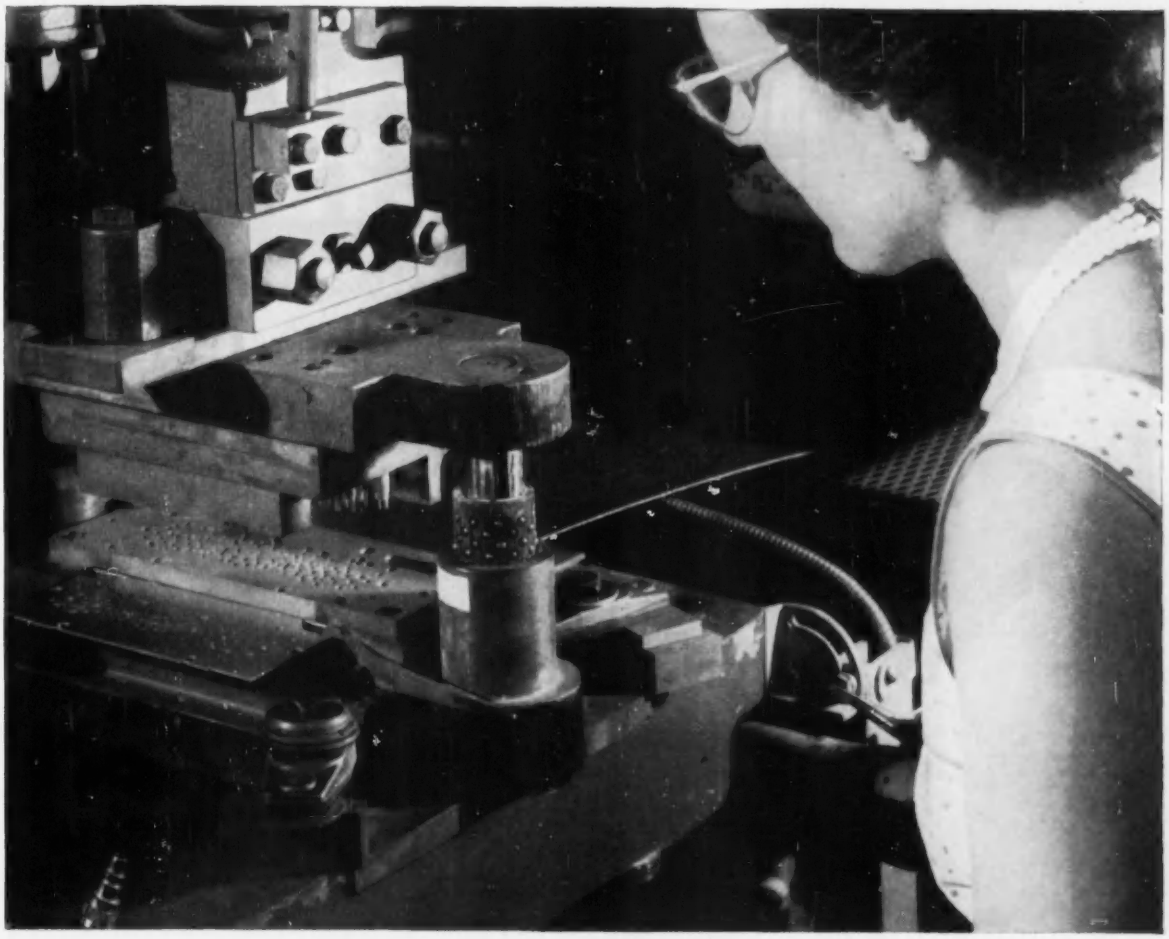
NAME_____
TITLE_____
COMPANY NAME_____
ADDRESS_____
CITY_____ ZONE_____ STATE_____

PARKER-KALON DIVISION, General American Transportation Corporation. Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts, Thumb Screws and Staps®.

Factory: Clifton, New Jersey

Warehouses: Chicago and Los Angeles

PARKER-KALON NATIONALLY ADVERTISED PRODUCTS ARE SOLD COAST-TO-COAST, BY LEADING INDUSTRIAL SUPPLY DISTRIBUTORS



New copper-clad **MICARTA**®
is easy to cold punch—no cracking, no chipping!

All holes in new H-3032 copper-clad MICARTA can be cold punched right on the assembly line in one operation, and there's no cracking, breaking or chipping. That is one of the reasons why this new laminate cuts costs and production time of printed circuits.

In addition, copper-clad MICARTA speeds up soldering, without the normal accompaniment of an increase in rejects and missed connections.

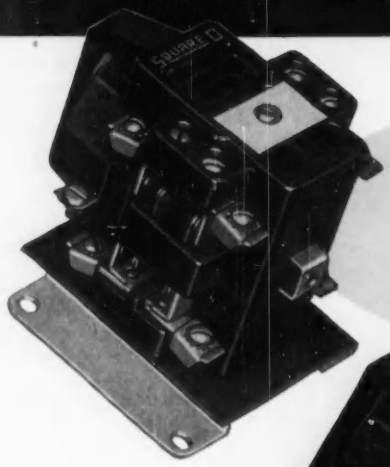
High bond strength — from 10 to 13 pounds versus an industry standard of six pounds — is retained even after heating and cooling are repeated many times, due to a new adhesive process.

If you have a circuit assembly problem, copper-clad MICARTA may be the answer. For further information and for technical data, write to Westinghouse Electric Corporation, MICARTA Division, Hampton, South Carolina. J-06626

CAN BE DIP SOLDERED! MICARTA will not blister — even when dip soldered for 10 seconds at 500° F. A special adhesive actually increases adhesive strength during soldering.

YOU CAN BE SURE...IF IT'S Westinghouse

A COMPLETE LINE OF



UP TO 4 CONTACTS
2 Normally Open
2 Normally Closed
Measures only
3-5/16" high x 2-5/8" wide!

UP TO 6 CONTACTS
4 Normally Open
2 Normally Closed
Measures only
3-11/16" high x 2-13/16" wide!

NEW!

UP TO 10 CONTACTS
Either 6 Normally Open and
4 Normally Closed or
8 Normally Open and
2 Normally Closed
Measures only
5" high x 3" wide!

600 VOLTS 10 AMPERES LONG LIFE
ALL THREE SIZES HAVE IDENTICAL MOUNTING HOLE DIMENSIONS

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

SPACE-SAVING RELAYS

Take Them Apart in 20 seconds...from the Front!
Not One Bit of Tear-Down Space Needed!

MOUNTING SIMPLIFIED
All three sizes have identical mounting hole dimensions

OUTSTANDING PERFORMANCE
Balanced construction reduces wear on single moving part...results in long life and safeguards against down-time

RESISTS DAMAGE
Plastic impregnated molded coil is unbreakable, operates cooler, is dimensionally stable and impenetrable by water and oil

20-SECOND DISASSEMBLY
Simply loosen two screws and the entire device is disassembled for normal maintenance

PACKAGED PARTS KITS
make normal maintenance easier than ever. Any way you look at it, these new relays are tops. Small in size—long on features and performance

for the Complete Story, write for Bulletin 8501-D
Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

Everybody's Ahead with Square D!

Up to 40% higher tightening torques keep a

—and only the combination of an UNBRAKO screw

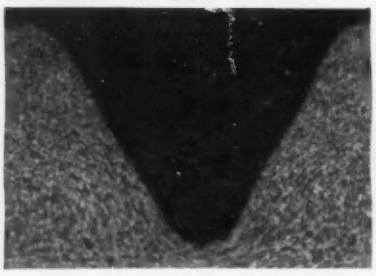
RECOMMENDED SOCKET SET SCREW TIGHTENING TORQUES (Inch-Pounds)

SCREW SIZE	UNBRAKO	SET SCREW B	SET SCREW C	MINIMUM DIFFERENTIAL %
#4	5	3.9	3.5	28
#5	9	7.8	7.4	15
#6	9	7.8	7.4	15
#8	20	14.7	14.5	36
#10	33	26.5	25	25
1/4	87	62	60	40
5/16	165	122	125	32
3/8	290	198	225	29
7/16	430	309	350	23
1/2	620	460	500	24
5/8	1225	1106	1060	11
3/4	2125	1540	1800	18
7/8	5000	3660	4600	9
1	7000	5025	6500	8

The High-Torque UNBRAKO socket set screw is made to withstand the highest tightening torques ever used to seat a set screw—up to 40% higher than an ordinary set screw. But to take full advantage of this UNBRAKO feature you must have a key that can apply the force required to seat it without damaging the screw or snapping the key. The High-Titan UNBRAKO hex key is designed specifically to set a High-Torque UNBRAKO so that you can be assured of full *high-torque* performance every time.

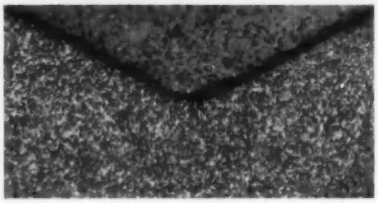
Here's why a High-Torque UNBRAKO can be seated tighter—and stay put

UNBRAKO SET SCREW



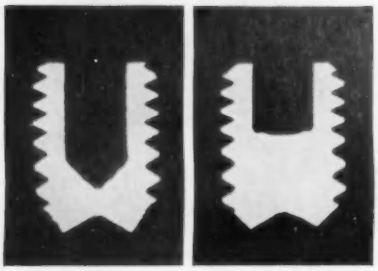
It has fully formed threads that make the whole screw stronger. The metal is compressed into the closely knit grain structure that you see in this illustration. The grain flow follows the contour of the threads. There are no straight lines along which shear can occur. The UNBRAKO retains its flow lines even when ground down to .010 in. below root diameter. Screws with cut or ground threads lose thread form at root diameter.

UNBRAKO SET SCREW



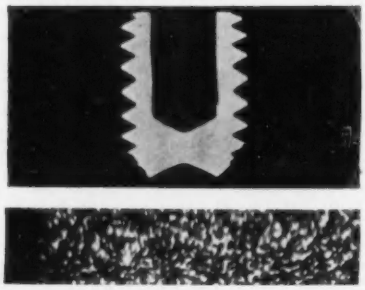
The High-Torque UNBRAKO has a radius in the socket corners. This eliminates the sharp corners where cracks start. It also distributes the stresses developed when tightening torques are applied. Ordinary socket screws have sharp corners which often crack when tightened even at lower torques than those recommended for UNBRAKO.

UNBRAKO SET SCREW **ORDINARY SET SCREW**



The High-Torque UNBRAKO has a deeper socket, which gives you more purchase with the wrench. Since more wrench can be put into the UNBRAKO socket, you can set the screw much tighter. And you won't ream the socket or round the corners of the wrench.

UNBRAKO SET SCREW

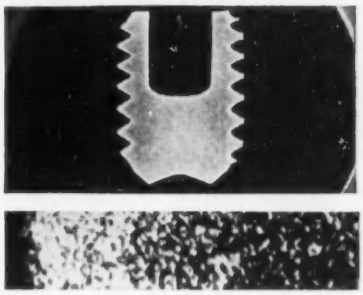


The High-Torque UNBRAKO is properly heat treated, kept clean. Its grain structure is uniform. It is free of decarburization. There's no danger of stripping the threads or shearing the point when tightening

High-Torque UNBRAKO socket set screw tight

and key assures full *high-torque* performance

ORDINARY SET SCREW



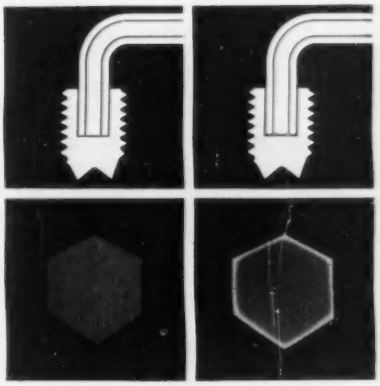
torques are applied. The ordinary screw is suffering from an overdose of decarburization; socket walls, threads and point are full of the telltale white spots that identify it.

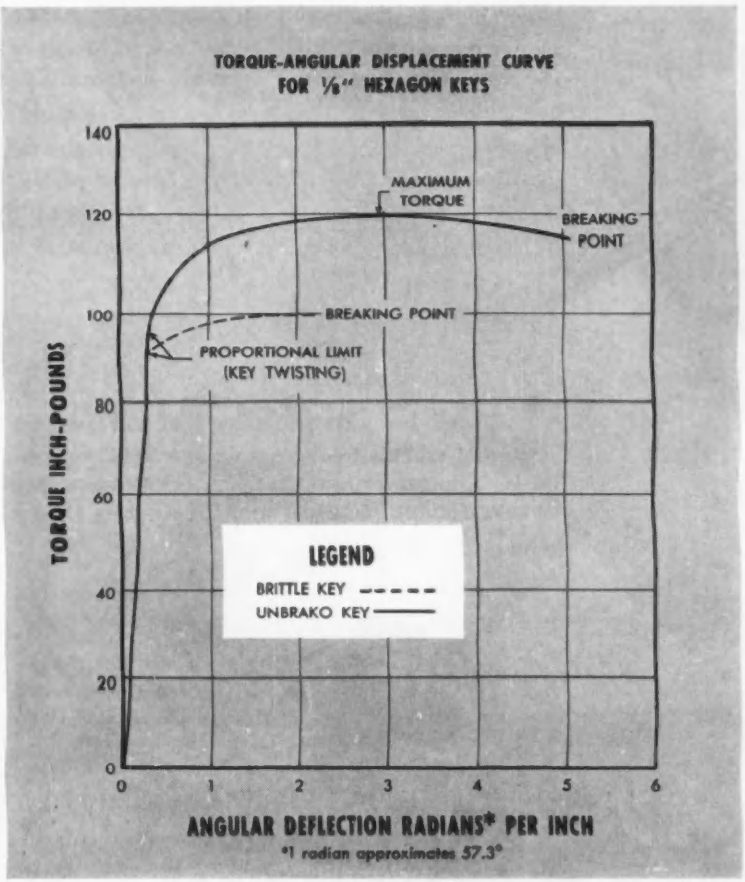
And here's why an UNBRAKO High-Titan hex key can be used to apply far more tightening torque to a High-Torque UNBRAKO socket set screw than is needed without damaging either the screw or the key.

The High-Titan UNBRAKO is not an ordinary hex key. It is a precision internal wrenching tool with high ductility, specially designed to assure full high-torque performance. It is made of special alloy steel bar stock, inspected magnetically and chemically to make sure that the material is flawless and of the specified properties. Its sides are flat and parallel. The corners, which exert torque on the inner walls of the socket, are sharp and tough. The bend is strong.

The High-Titan UNBRAKO is accurately sized across the flats and across the corners to insure snug fit and full wall contact. It won't ream or wear an UNBRAKO socket. The square cut end engages the full depth of the socket for greater tightening power. It gives you up to 25% more wrench engagement than a key with a chamfered end.

UNBRAKO KEY **CHAMFERED END KEY**





The High-Titan UNBRAKO hex key is heat treated in modern atmosphere-controlled furnaces. The surface is casehardened without decarburization. The extra hard surface gives the key longer life. And it retains its dimensional accuracy, is tougher and more ductile than ordinary keys. This torque-angular displacement curve for 1/8 in. hexagon keys distinguishes a High-Titan UNBRAKO from an ordinary key. The High-Titan UNBRAKO has a higher yield point and a higher breaking point—you can exert a much higher torque with it without snapping the key.

Be sure you get the full high-torque performance offered only by the combination of a High-Torque UNBRAKO socket set screw and a High-Titan UNBRAKO hex key. Both products are stocked by authorized industrial distributors. Ask the one nearest you for complete information. Or write STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

We also manufacture precision titanium fasteners. Write for free booklet.

Unbrako Socket Screw Division **SPS** **Jenkintown, Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Cooper Precision Products • Standco Canada, Ltd. • Unbrako Socket Screw Co., Ltd.

Here's a control valve that assures you

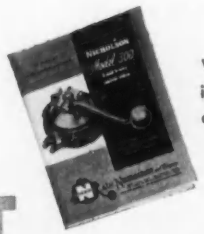
leak-proof service

Highly-lapped metal-to-metal surfaces of this Nicholson control valve assure you leak-proof service. The O-ring stem packing and O-ring seal between the body and base make joints leak-proof without excessive bolt tension.

You can use the Model 300 with air, water, hydraulic fluid or oil as the pressure medium . . . at operating pressures to 300 psi. Use it to activate single- or double-acting cylinders. Simple and rugged, this valve provides accurate, repeatable control of equipment such as presses, hoists, clutches and chucks. Valve maintenance is no problem . . . all stem, base and disc bearing surfaces are lubricated through one easily accessible fitting on top of valve stem. Lubricant reservoir in base reduces frequency of lubrication.

No need to stock valves or parts for service with different pressure mediums. This valve's *one* combination of corrosion-resistant materials—bronze body, aluminum-bronze base, stainless-steel disc, hard chrome-plated stem—is well suited for all of the most commonly used pressure mediums. It's available in three pattern sizes covering five standard pipe sizes from ¼" to 1" . . . small enough and light enough to be supported by connected piping.

For a 3- and 4-way control valve that will give you leak-proof, trouble-free operation, specify Nicholson. W. H. NICHOLSON AND COMPANY, 14 OREGON ST., WILKES-BARRE, PA. Sales and Engineering Offices in 98 principal cities.



Write for Bulletin 300 . . . covering design, construction, sizes and applications for the Model 300

NICHOLSON

OF WILKES-BARRE

Self-aligning

FOR LONGER LIFE

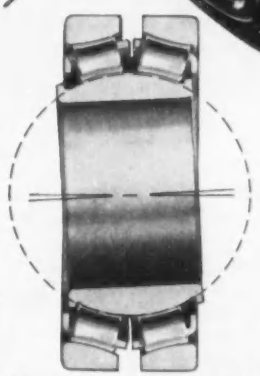
Not even misaligned shafts or supports impair the efficiency of this easy-to-mount LINK-BELT roller bearing

THE equipment manufacturer seeking lower manufacturing costs plus the ultimate in free-rolling efficiency need look no further than this Link-Belt roller bearing.

- **SELF-ALIGNMENT** compensates for inaccuracies in machining and assembly of equipment.
- **EASY MOUNTING.** Bearing is securely and quickly locked by a heavy collar to commercial shafting.
- **COMPACTNESS** offers design flexibility.

You'll find equally important economies throughout industry's most complete line of ball and roller bearing blocks. Ask any one of 40 Link-Belt offices for Book 2550 containing full information.

Series 400 roller bearings



FREE ROLLING—SELF ALIGNING. Spherical inner ring aligns freely in any direction. Load is distributed over entire roller, assuring full capacity. Destructive edge loading cannot occur.

LINK LB BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14 440-A

PowerGrip "TIMING" BELTS

"Here's how to sharpen the brains of memory machines,"

says Plant Engineer **"GRIP" POWERS**

SCHEMATIC OF U.S. POWERGRIP "TIMING" BELT DRIVE
ON BOESCH TOROID WINDER (MODEL SM-C)
(A) ⅛ hp motor pulley—3450 rpm, 1¾" diam.
(B) jack shaft pulley—2156 rpm, 2¹³⁄₁₆" diam.
(C) jack shaft pulley—2156 rpm, 1¾" diam.
(D) grooved idler—fixed, 1¹⁄₃₂" diam.
(E) spring loaded idler—1¹⁄₃₂" diam. Pivot arm, attached to spring, compensates for manufacturing tolerances and travel of (F).
(F) spindle head pulley—3800 rpm, 1¹⁄₃₂" diam. Pulley can be moved 1", in near-flat arc, to set before winding toroid core.
Because of very short centers, small pulley diameters, high speeds and the need for precise control, Boesch selected PowerGrip drives. They have simplified the machine, made it more compact, and more than doubled the life of the drive.
1"
7"
3"
(TB)
(TB)
7"
(A)
(B)
(C)
(D)
(E)
(F)

The "brains" of electronic memory machines are centered in toroids—tiny, doughnut-shaped coils of thousands of turns of tightly wound wire. Winding these toroids requires the utmost precision. That's why Boesch Mfg. Co. (Danbury, Conn.), a leading maker of toroid winders, uses U.S. PowerGrip "Timing"® Belts on their power transmission drives.

U.S. PowerGrip "Timing" Belts have an efficiency of close to 100%. The belts need no lubrication, no maintenance, are more accurate and quieter than drives formerly used and far safer to both operator and machine.

Says the chief engineer of Boesch: "We also use U.S. PowerGrip on our toroidal tape winders and bobbin winding machines. Our engineers and 'U.S.' engineers work hand in hand on *all* our wind-up problems involving power transmission."

A complete line of PowerGrip "Timing" Belt drives—plus expert power transmission engineering assistance—is obtainable at any of the 28 "U.S." District Sales Offices, at selected distributors, or write U.S. Rubber, Mechanical Goods Div., Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Co. Ltd.

Mechanical Goods Division

United States Rubber

SEE THINGS YOU NEVER SAW BEFORE. VISIT U.S. RUBBER'S NEW EXHIBIT HALL, ROCKEFELLER CENTER, N.Y.

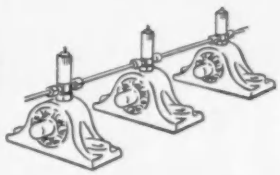
Design for

Automatic Lubrication From One Central Point

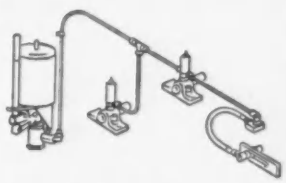
with an ALEMITE Accumatic® System

FASTER . . . FOOLPROOF . . . LESS COSTLY!

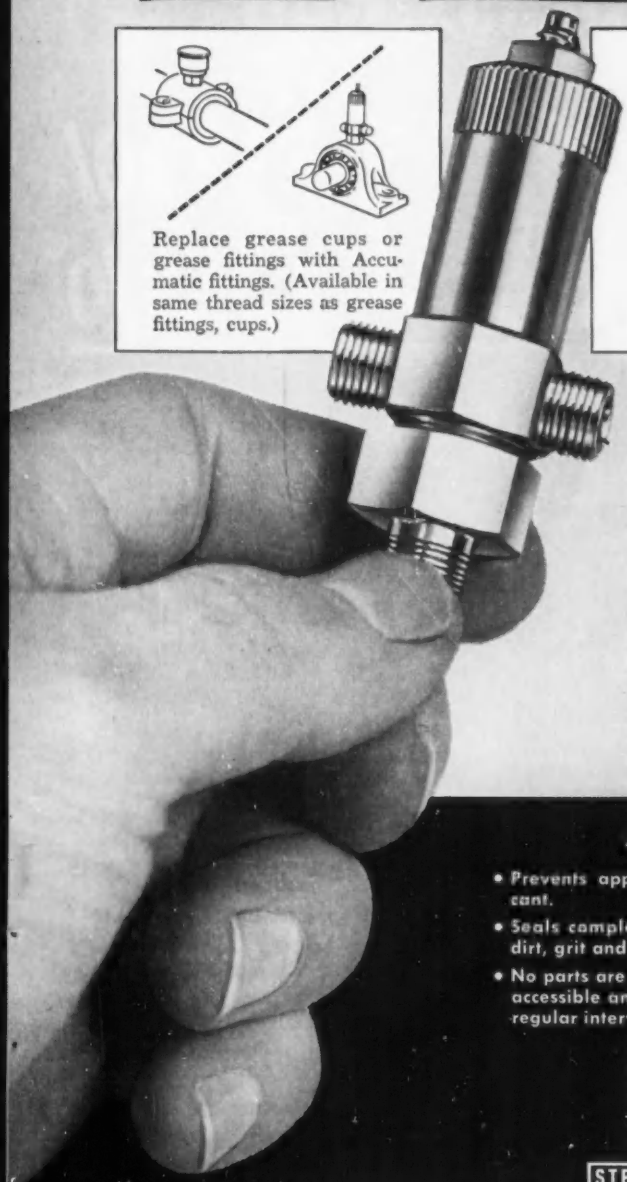
Replace grease cups or grease fittings with Accumatic fittings. (Available in same thread sizes as grease fittings, cups.)



Connect Accumatic fittings with copper tubing. (Alemite has tubing, clips and accessories for easy installation.)



Connect sliding, rotary or oscillating parts into tubing system. (Flexible hose and swivels for moving parts.)

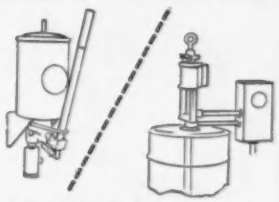


Type 1 Accumatic Valves

For fluid oil or light grease. In range of sizes, delivering from .005 to .100 cu. in. of lubricant. Various shapes: Tees, straight-thru, inserts, angles. Spring pressure provides gradual feed. Adjustable or fixed output. System serves up to 400 bearings. Manual or automatic operation available.

Factory-tested—field-proved!

Grueling field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—equal to 122 *years of twice-a-day service!*



Provide central pump to supply lubricant to system. (Ordinary hand pump or fully automatic barrel pump.)

ALEMITE ACCUMATIC ADVANTAGES!

- Prevents application of wrong lubricant.
- Seals completely against damaging dirt, grit and water.
- No parts are neglected—lubricates inaccessible and dangerous bearings at regular intervals.
- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods—services all bearings in one operation.
- Delivers *exact* amount of lubricant to bearing.

FREE! Alemite Accumatic Catalog

Alemite, Dept. AA-97
1850 Diversey Parkway, Chicago 14, Illinois
Please send me my free copy of the complete Accumatic Catalog.

Name .....

Company .....

Address .....

City ..... Zone ..... State .....

ALEMITE
REG. U. S. PAT. OFF.

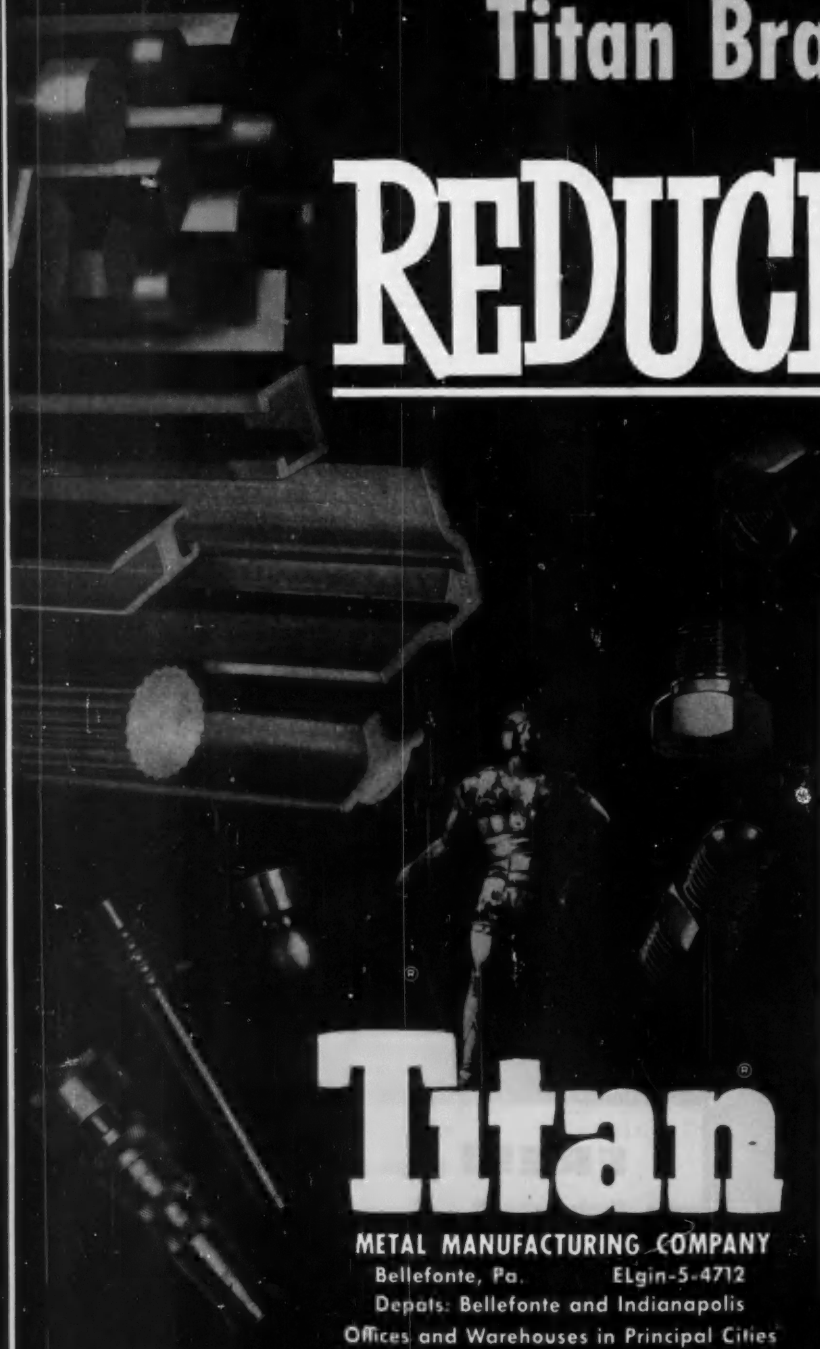
A Division of STEWART-WARNER CORPORATION

STEWART SW WARNER

"Why substitute? The best metal for screw machine parts is still brass... and it costs less!"

Titan Brass Rod

REDUCED 32%



Price of Titan free-cutting brass rod today is reduced over 15 cents per pound, or 32% from April 5, 1956 . . . from 47.51 cents per pound to 32.23 cents per pound on August 6, 1957.

Be cautious about substitution claims. Remember these advantages of brass:

- Brass is the most easily machined of all metals . . . giving low costs and high output
- Brass allows trouble-free maintenance on screw machines
- Brass has natural fine surface for high polish and ready plating
- Brass gives maximum production efficiency . . . eliminates extra operations
- Brass is corrosion-resistant
- **Brass scrap has the highest market value of all common metals**

It all adds up. Brass gives you your metal money's worth! And brass costs less. Call Titan today!

Titan®

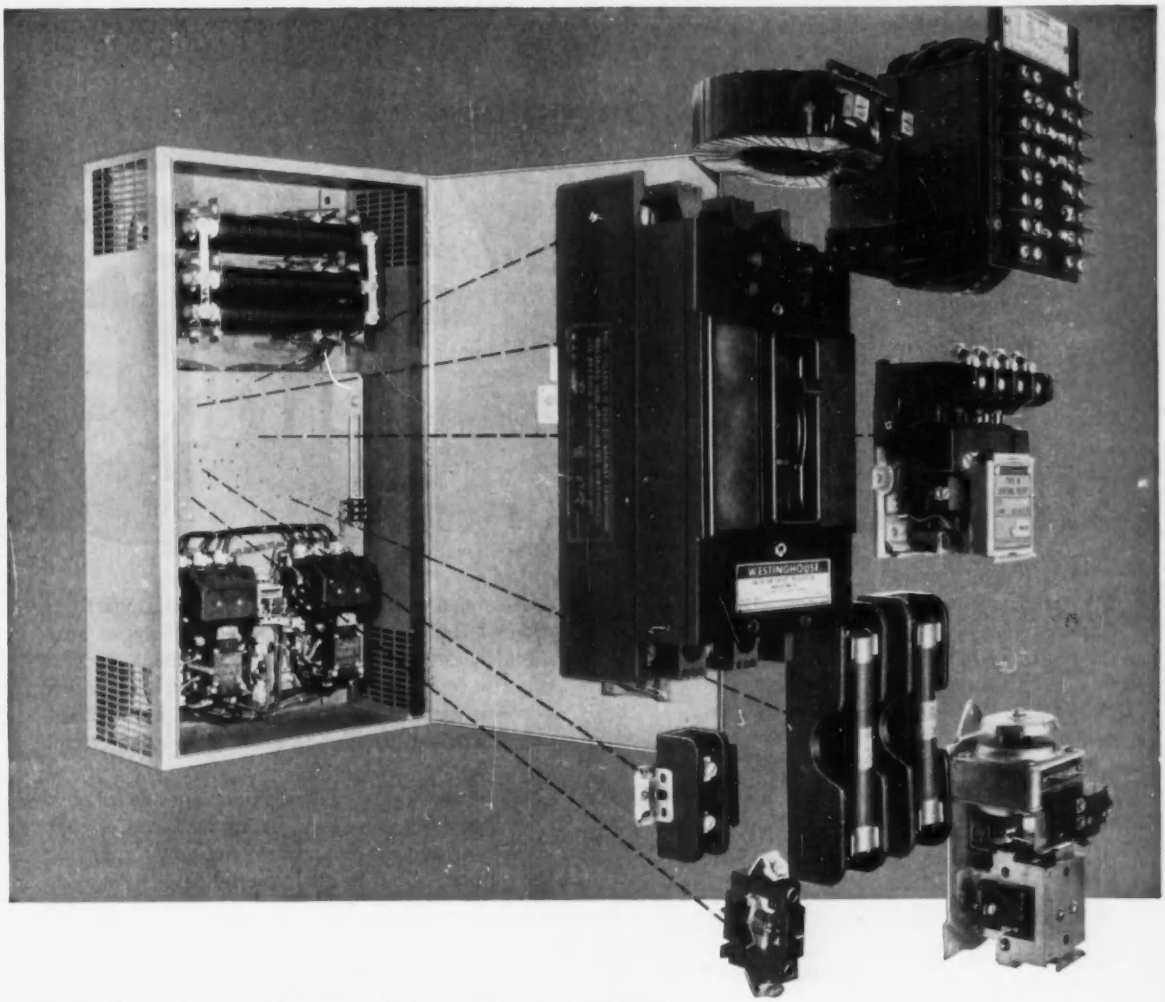
METAL MANUFACTURING COMPANY

Bellefonte, Pa. ELgin-5-4712

Depots: Bellefonte and Indianapolis

Offices and Warehouses in Principal Cities

TITAN BRASS FOR FORGINGS AND DIE CASTINGS HAS BEEN REDUCED PROPORTIONATELY!



REDUCED VOLTAGE STARTER

. . . built to grow with Add-A-Part Panel

Room to grow is built right in at the factory with the Westinghouse Add-A-Part panel. When additions to systems require such modifications as control circuit fuses, auxiliary relays, or current transformers, the space for them is there—engineered right into industry's most advanced reduced-voltage starter.

Other features that make this starter the most flexible, available today include pneumatic types AM and AMB relays for easy, stepless timing adjustment—adjustable resistor taps so you can adjust starting voltages to meet your requirements.

For all the facts, call your Westinghouse sales engineer. Ask for DB 11-500. You'll see one more reason why you can be sure . . . if it's Westinghouse. J-22022

YOU CAN BE SURE...IF IT'S

Westinghouse

When It Comes to Your Reproduction Equipment...

It May Be LATER Than You Think!

If more than a few years have gone by since you acquired your reproduction equipment, chances are it's costing you unnecessary time, man hours, and money. It may well turn out to be a bottleneck in your efforts to meet growing production boom demands.

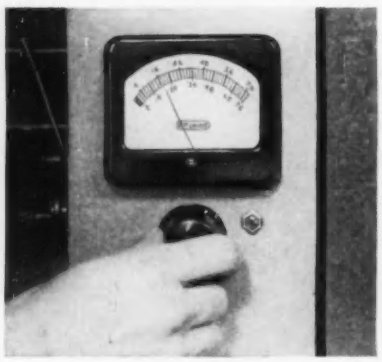
Compare your equipment with the modern Bruning machines shown here. You should be getting the advantages offered by such advanced models as the new "575"... greater mechanical speeds, faster return of originals, synchronized exposure and development, automatic separation of originals from exposed prints, automatic stacking, front or rear print delivery. You should be benefiting by the problem-free installation and operation of Copyflex —no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection.

If you're not getting these important advantages, then every day you delay getting modern Copyflex is costing you time and money. Act now by mailing the coupon. You'll be glad you did!

Copyflex Gives You All These Modern Reproduction Advantages!

Greater Convenience of Operation!

Modern Copyflex gives printing widths up to 54" to simplify feeding of large tracings, facilitate multiple feedings. Such features as extra-large delivery trays, automatic separation, and front-or-rear delivery further speed operator's work.



Faster Mechanical Speeds!

New Copyflex models introduced within the past two years offer sharply increased speeds—up to 30% faster than before. Synchronized exposure and development assure top quality prints, one knob control simplifies operation.

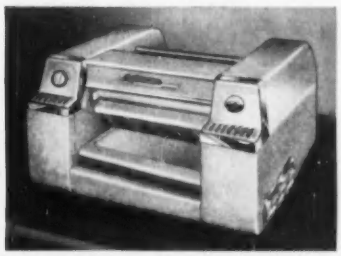
Problem-Free Installation and Operation!

Clean, quiet, odorless... Copyflex requires no vents or plumbing. Precision-engineered design, including use of selenium rectifiers instead of troublesome vacuum tubes, assures trouble-free operation.

Just Out! *New, 75 f.p.m. Copyflex Model 575!*

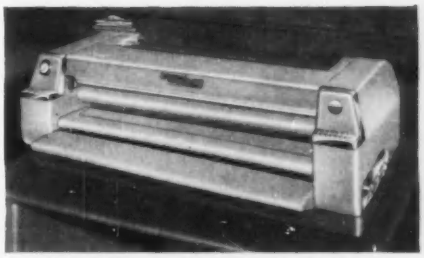
Now when you need it! Here is the fastest, easiest-to-use Copyflex machine ever built!

Here is the whiteprinter that has everything you could want in a reproduction machine —a super-fast mechanical speed of up to 75 feet per minute, a fast-printing exposure lamp which can be operated at either 7,500 or 5,000 watts with the flick of a switch, a full 46-inch printing width—*plus* many operator conveniences. The powerful, two-stage lamp provides the proper latitude for assuring the production of sharp, high contrast prints of all types of translucent originals at the fastest possible rate. Operator conveniences include: one-knob speed control, with perfect, automatic synchronization of print exposure and development; improved, air-foil type automatic separation of exposed prints from originals; automatic stacking of tracings and prints; front or rear delivery; and a lamp shield control which facilitates the reproduction of extra-fast printing originals. The new Model 575 will pay for itself many times over in your drafting room by bringing you increased savings in time and man hours.



Model 110. When you need prints of such smaller size originals as specification sheets and check prints, this handy table-top machine turns them out in a jiffy without tying up your big machine. It has a printing width of 11". Makes 8½ x 11 prints for less than 1¢ each for materials. Operates on 115 volt A.C.

Model 250. It takes less than a square yard of floor space, yet offers a printing width of 18½" and a fast mechanical speed of 30 f.p.m. Automatic separation and stacking, one-knob control, and an extra-large feed board simplify and speed operator's work. Operates on 220 volt A.C.



Model 300. It's only 46" wide, yet offers a full 30" printing width! This remarkable low-priced table-top machine brings "inside" reproduction within the means of the smallest department or firm, makes an ideal "extra" machine for large companies. Operates on 115 volt A.C.

BRUNING *Copyflex*

Best Process! Best Machines!
Best Selection of Materials!

Offices in 38 Cities of the U.S. and Canada

CHARLES BRUNING COMPANY, INC., CHICAGO

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto, Ont.

Charles Bruning Company, Inc., Dept. 93-0
4700 Montrose Ave., Chicago 41, Illinois

Please send me information on the Copyflex process and the following Copyflex machines: _____

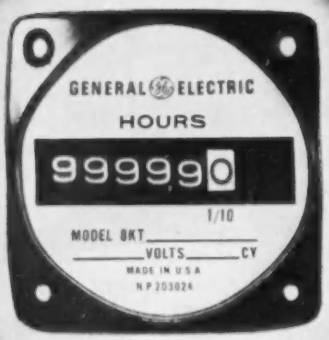
Name _____ **Title** _____

Company _____

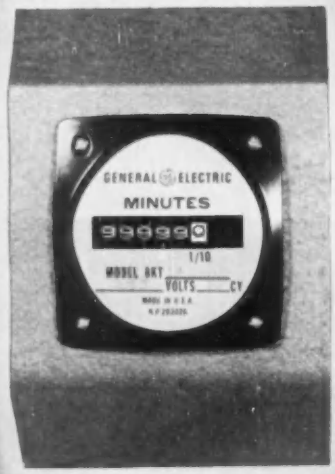
Address _____

City _____ **County** _____ **State** _____

Round model for panel mounting.



Square model for panel mounting.



Portable model for laboratories.

Conduit case for easy installation.

NEW General Electric Time Meters cost less, read easier, give wider range of measurement

ALL DIGITS 2½ TIMES LARGER—NEW, EXTRA DIGIT GIVES WIDER RANGE FROM 0 TO 99999.9 HOURS OR MINUTES

OLD
(Life Size)

NEW
(Life Size)

At a new, low cost, General Electric now offers you a complete line of time meters for measuring operating time of every type of electrical equipment.

Available in 2½ and 3½ inch sizes these new General Electric Time Meters offer you these important benefits:

- **DUST-PROOF PROTECTION . . .** due to totally enclosed construction. Sealed models also available to military specifications.
- **RESET MODEL . . .** conveniently located reset knob available (optional) on all General Electric Time Meters except sealed models.
- **INCREASED OPERATING TEMPERATURE RANGE FROM** —67F to 150F . . . means more flexible application and longer meter life.

3 WAYS YOU BENEFIT WITH GENERAL ELECTRIC TIME METERS:

LOWER COST, BETTER PLANNED MAINTENANCE . . . because you can measure the operating time of your equipment, thus allowing you to apply pre-planned productive maintenance.

LESS DOWNTIME, FEWER PRODUCTION LOSSES . . . because you can measure the total operating life of your equipment, and thus replace it on a scheduled basis before it breaks down unexpectedly.

BETTER UTILIZATION OF MANPOWER AND MACHINES . . . because General Electric Time Meters measure the shutdown time of your equipment, allowing efficient scheduling of employee and machine work assignments.

FOR AN ACTUAL DEMONSTRATION of how these new General Electric Time Meters can help you save money and improve operating performance, call your nearest General Electric Apparatus Sales Office. And write today for descriptive bulletin GEA-6710, General Electric Company, Section 584-12, Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

why you can depend on REVERE!

1 A wide selection of shapes (rounds, squares, rectangles, etc.) . . . *mechanical or pressure* tubing . . . produced to fit your specific needs.

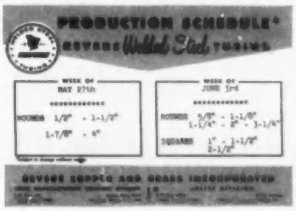
2 Continuing set-ups of popular sizes assure *speedy delivery* . . . sizes range from ¼" O.D. to 5" O.D. with proportionate sizes in squares, rectangles and special shapes.

3 Wall thicknesses range from *.028" to .250"* and *.065" to .250"* depending upon the size and grade tube . . . C-1010 to C-1030 steels are available . . . coated or low alloy — high strength steels may also be specified.

4 *Complete facilities* for annealing, normalizing, sink or mandrel drawing and hydrotesting. . . . Do you have a special fabrication requirement?

All of these features are backed by REVERE'S more than *35 years' experience* in producing electric welded steel tubing for every type application. *Try REVERE next time! You'll be glad you did!*

KEEP YOUR PRODUCTION ON SCHEDULE—KEEP IN TOUCH WITH REVERE



Shown at left is a sample of the card mailed every two weeks, in advance, showing Revere's Production Schedule. Our customers have found it to be extremely helpful. Shall we place your name on the list? No obligation, of course, and you need not be a Revere customer.

Send today for these two informative booklets: 1 — Revere Welded Steel Tubing Catalog. 2 — Commercial Tolerances for Welded Steel Tubing.

REVERE COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
Rome Manufacturing Company Division
Box 111 Rome, N. Y.

WELDED STEEL 18 01 REVERE TUBING

MICRO SWITCH Precision

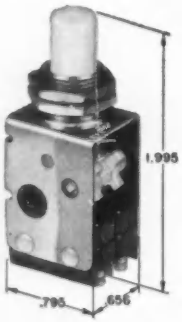
...FIRST IN PRECISION SWITCHING

Here are 6 NEW Precision Switches by MICRO SWITCH...

Designed to meet modern electrical control requirements

■

MICRO SWITCH pioneered the development of precision switches... It has been first in precision switching for two decades... These new switches are typical of MICRO SWITCH's continuing leadership.



NEW!

MICRO SWITCH alternate action pushbutton switch gives on-off control of up to four circuits

Shown here is the MICRO SWITCH 82PB1-T2 (unlighted) which allows on-off control of up to four circuits. When the switch button is pushed, the contacts of the switches are alternately reversed. They complete a cycle of action every two operations of the button.

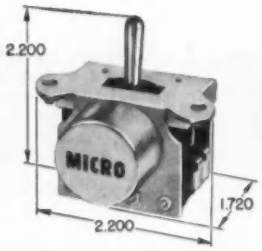
This alternate action is achieved by the extremely compact design of a long-life assembly of ratchets. Variations are possible which will permit almost any sequence of switch operation. For instance, on a switch with a four-push sequence, a great many sequences of switch operation can be provided.

This switch requires but 1⅛ in. below its mounting panel and mounts in a ½ in. hole. Button is of off-white plastic. Operating force is 35 oz. max.

(Send for Data Sheet 124)

SWITCH CHARACTERISTICS

Two SPDT switches; break distance .010 in. min. Electrical data: U/L listed at 5 amps. 125 or 250 vac; 30 vdc rating: inductive, 3 amps. at sea level and 2.5 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet. Maximum inrush is 15 amps.



NEW!

MICRO SWITCH magnetic hold-in toggle switch—permits remote release of toggle lever to its unoperated position

This MICRO SWITCH 2ET1 magnetic hold-in toggle switch is a momentary-action toggle switch which also functions as a maintained-contact switch by means of a solenoid incorporated into the design of the switch. When the toggle lever is operated and the solenoid is energized, the magnetic force of the solenoid holds the switch in the operated position. This magnetic hold-in feature permits remote electrical release of the lever.

The precision SPDT switch and a 28 vdc solenoid are contained in one compact unit. The small size makes it an ideal component for applications where space is a critical factor. *(Send for Data Sheet 137)*

SWITCH CHARACTERISTICS

Total travel 30°; Electrical data: 28 vdc rating: inductive 3 amps. at sea level and 2.5 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet; motor, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet; Hold-in rating of solenoid is 18-30 vdc.

Switches have uses unlimited

NEW!

MICRO SWITCH "Rocket Switch"— a rugged, sealed small switch for indicating and lockout devices

Developed for use on rocket launchers, this MICRO SWITCH 21AS2 assembly fits the needs of many industrial designs.

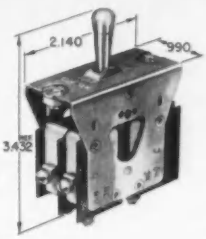
The assembly consists of one SPDT Type-EN switch attached to a rugged cam-type actuator. The assembly is environment-proof and withstands the highly-corrosive effects of rocket propulsion gases. The assembly will withstand heavy impact hammer blows on the actuator.

(Send for Data Sheet 120)

SWITCH CHARACTERISTICS

Operating force—6 to 12 lbs. Full overtravel force—10 lbs. min.; Release force—4 lbs. min.

Electrical Data: 28 vdc rating: inductive, 3 amps. at sea level and 2 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet. Motor, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet. (Altitude ratings established with seal deliberately broken.)



NEW!

MICRO SWITCH three-position toggle switch—4 SPDT circuits with a single lever

MICRO SWITCH 115AT Series of toggle switches uses four SPDT switching units. Two units are actuated in each extreme toggle lever position. None are actuated when lever is in center position.

Many different combinations, however, may be obtained, including the make and break of circuits in all three lever positions.

Outstanding features of this series include the compact design, positively-driven switch actuators and sturdy construction. A safety catch guards against accidental movement of toggle lever. *(Send for Data Sheet 132)*

SWITCH CHARACTERISTICS

Electrical rating at 30 vdc: inductive—10 amps. at sea level, 6 amps. at 50,000 ft.; resistive—10 amps.; motor—6 amps. Basic units listed by Underwriters' Laboratories for: 10 amps. 125 or 250 vac; ½ amp. 125 vdc; ¼ amp. 250 vdc.

NEW!

MICRO SWITCH completely sealed magnetic hold-in toggle switch

The MICRO SWITCH 5ET Series is a completely sealed momentary action toggle switch which also functions as a maintained contact switch. When the toggle lever is operated and a solenoid is energized, the magnetic force holds the lever operated. This hold-in feature permits remote electrical release of the lever.

Both switch and solenoid are sealed within the cylindrically shaped enclosure. This insures constant operating characteristics. An elastomer seal at the base of the toggle lever prevents entrance of dust or moisture. *(Send for Data Sheet 121)*

SWITCH CHARACTERISTICS

Total travel 30°; Contact arrangement SPDT, may be wired either N. O. or N. C. Electrical rating at 28 vdc: inductive, 3 amps. at sea level and 2.5 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet; motor, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet; Hold-in rating of solenoid is 18-30 volts dc.

NEW!

MICRO SWITCH "typewriter" pushbutton switch for manual keyboard control

MICRO SWITCH 1PB81-T2 switch is ideal for one-finger rapid-repeat operation such as is required for the type of keyboard control found in electric typewriters, adding machines, etc. The repeat action is as rapid as the fastest operator can push the button.

This switch uses a SPDT MICRO SWITCH subminiature switch for snap-action reliability. The contoured button and unique overtravel spring combine to reduce operator fatigue. Operating "feel," however, is sufficient to avoid mistakes and false actuations.

Removable ½ in. dia. plastic button is available in red, green, off-white or black. It is keyed to prevent rotation. *(Send for Data Sheet 125)*

SWITCH CHARACTERISTICS

Electrical rating at 30 vdc: inductive—3 amps. at sea level and 50,000 ft.; maximum inrush—15 amps. Basic subminiature switch is listed by Underwriters' Laboratories at 5 amps. 125 or 250 vac.

MICRO SWITCH

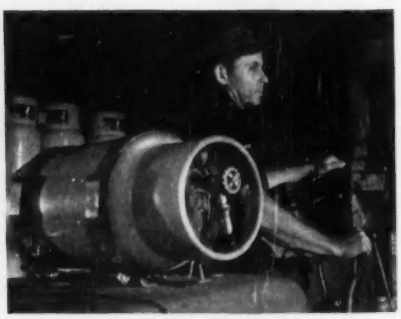
A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Here N-A-X FINEGRAIN *steel proves its versatility, forming readily under the deep-drawing operation that pressure cylinder manufacturing requires. For 20-lb. cylinders, .086"* N-A-X FINEGRAIN *blanks, 21¼" in diameter, become 12" in diameter and 7½" in depth after the drawing operation. Steel Cooperage Division produces cylinders up to 425-pound capacity.*

Submerged arc welding operation joins the two cylinder sections together. N-A-X FINEGRAIN *again demonstrates its weldability under any process.*

Here cylinder pressure capacities are tested hydrostatically at 480 lbs. psi, after the fittings have been added. Final burst pressure—1650 lbs. psi.



Finished product on the job. This cylinder, meeting all specifications of I.C.C. code, Section 4BA, contains liquefied petroleum for materials handling truck.

For whatever you make . . .

N-A-X® FINEGRAIN STEEL BUILDS IN STRENGTH WITH LIGHT WEIGHT

A significant example of the strength, formability and weldability of N-A-X FINEGRAIN steel is to be found in the manufacture of liquefied petroleum gas cylinders by Steel Cooperage Division of the Serrick Corporation, Detroit.

These lightweight LP-Gas cylinders must be able to withstand high internal pressures. Therefore, the steel used in their manufacture must have a minimum yield strength of 50,000 pounds per square inch and a tensile strength of 70,000 pounds per square inch, in order to meet the requirements of Section 4BA of the I.C.C. specifications.

On this job, as with so many others, N-A-X FINEGRAIN steel resulted in lighter weight, without sacrifice of strength and safety.

Check these important advantages for your job: N-A-X FINEGRAIN steel, compared with carbon steel, is 50% stronger • has high fatigue life with great toughness • is stable against aging • has greater resistance to abrasion • is readily welded by any process • offers greater paint adhesion • polishes to a high luster at minimum cost. And the physical properties of N-A-X FINEGRAIN are inherent in the "as rolled" condition. N-A-X FINEGRAIN'S resistance to normal atmospheric corrosion is twice that of carbon structural steel. NOTE: Where greater resistance to extreme atmospheric corrosion is an important factor, our N-A-X HIGH-TENSILE is recommended.

For whatever you make, from pressure cylinders to tractors, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight, and economy, into your products. Let us show you how.

N-A-X HIGH-STRENGTH STEELS

N-A-X Alloy Division, Dept. C-5

GREAT LAKES STEEL CORPORATION

Detroit 29, Michigan • Division of

NATIONAL STEEL CORPORATION

N-A-X Alloy Div., Dept. C-5

Great Lakes Steel Corp., Detroit 29, Michigan

☐ Please send me technical data on N-A-X FINEGRAIN steel.

☐ Please have your representative contact me.

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

NAUGATUCK Paracril

THE OIL-RESISTANT NITRILE RUBBER

superior ozone resistance ● greatly increased flex life ● even higher abrasion resistance

The secret of obtaining these valuable new properties in the vulcanizate lies in a method—recently developed by Naugatuck research—of compounding PARACRIL® with other inexpensive materials. The additives modify and fortify the PARACRIL, greatly expanding its range of application. For example, in the manufacture of hose intended to carry or be used around oil or petroleum distillates, PARACRIL can now be used to make long-lasting *outer jackets* and oil-resistant tubing.

The compounding secret that makes PARACRIL the *ideal all-around oil-resistant rubber* is available to PARACRIL users from Naugatuck's synthetic rubber and rubber chemicals technical representatives. Write or wire to have one of them call on you.

Naugatuck Chemical

Division of United States Rubber Company, Naugatuck, Connecticut

US RUBBER

CANADA: Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario • Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • CABLE: Rubexport, N.Y.

PERSPECTIVES

in design and development . . .

Engineers Here And Abroad

The old English proverb, "Misery loves company" led us to check the engineering manpower situation in other countries. The result: we have plenty of company. A shortage exists in all nine of the countries checked, but many see the situation brightening. Here are the reports:

Netherlands

There is a shortage of both types of engineers trained here: the Technical University (Delft) and the technical colleges (MTS). While both do engineering work, only the Delft graduates are called engineers and many are in management. The smaller companies for the most part use MTS engineering graduates. But the larger companies are employing engineers as well as MTS graduates.

At the technical college level (MTS), shortages in the manufacturing industry amount to about 15%. Shortages are most serious in all branches —civil, chemical, mechanical and electrical. The same holds true for the university graduates (Delft). The shortage of both groups is estimated at 2025, of which 1384 are in the metal and ship-building industries. Since 1954, there has been a decline in the number of graduates from the Delft University, with no upturn seen until 1960.

Some American engineers are working in the Royal Dutch plants at pay equal to that of the U. S. The average annual salary of a Dutch university trained engineer (on the level of a department head) is $3,500, and that of the college trained engineer about $2,000.

Sweden And Norway

Industry's manpower shortage in Sweden is estimated to be 6% of the existing total. State, and municipal agencies and enterprises add 15%.

The overall number of engineers in Sweden has risen from 23,000 in 1940 to 57,800 in 1955. This figure is expected to reach 90,000 by 1965. Of the 57,800 engineers active in 1955, 10,600 held a Civilingenjoer degree, which corresponds to a Master of Science.

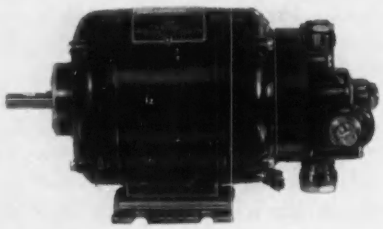
During the past ten years, in both Norway and Sweden many industrial companies have been shelving product development programs and postponing research in favor of more immediate problems like stepped-up production. This trend may now be reversed and the demand for design engineers is likely to increase. In greatest demand in Sweden are mechanical and electrical engineers. This applies particularly to those specializing in control engineering and electronics in general. This lack of trained control engineers is said to be the main bottleneck in a continued development of automation. In Norway the great demand is for metallurgical engineers.

It is understood that there is an agreement between government agencies and private industry which prohibits the pirating of government engineering manpower. Pirating may exist between individual companies, but it is unlikely to be of any major scope.

Many top management posts in Swedish industry are held by people with an engineering degree. A design or project engineer with a Civilingenjoer degree will start with an average salary of $280 a month and reach $600 within 15 years. Comparative figures for engineers with lower degrees are $180 and $440. This is the official rate of exchange, but figures may be doubled if actual purchasing power is considered.

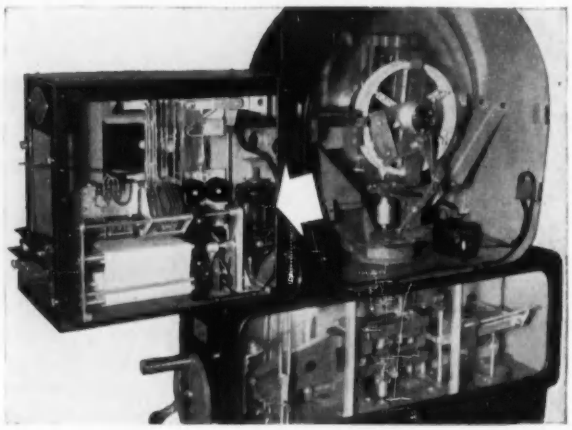
(Continued on page 63)

Fairbanks-Morse Printomatics use BODINE MOTORS because . . . "THEY ARE COMPACT, WITHSTAND YEARS OF HARD USAGE"

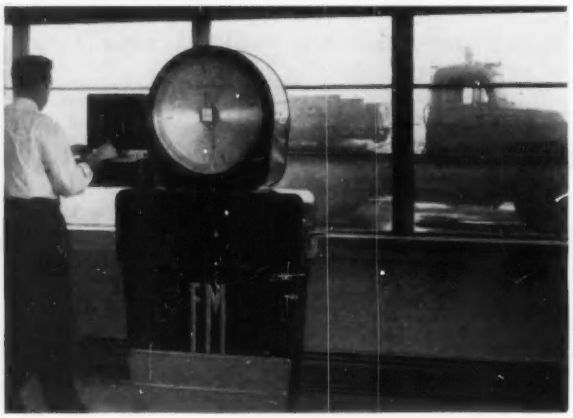


Bodine Type NSI-12R reducer motor

This Bodine motor is used in the Fairbanks-Morse Printomatic which prints a record of each weighing. The outstanding service record set by Bodine motors over the past twenty years—under the adverse operating conditions at truck weighing stations, and the high-speed weighings in industry—is the reasor. Bodine motors are "standard" on all Fairbanks-Morse Printomatics.



Here's an inside view of the Fairbanks-Morse Printomatic showing how the compact Bodine motor is positioned. This 1/70 HP, 1725 rpm reducer motor with a gear ratio of 72:1 actuates the selector fingers, which set type segments in the correct sequence, and then prints the indicated weight. This Bodine motor is often called upon to print weighings at rates up to 300 and 400 an hour.



Equipped with the Printomatic, this modern Fairbanks-Morse Scale combines precision performance with dependable and convenient recording. Printomatic units can be furnished with press keys to identify source of material, dates, quantities, payment, and other desired information at the time of weighing.

Mr. H. M. Goodchild, chief engineer, Fairbanks, Morse & Co., St. Johnsbury Works, gives the reasons they have standardized on Bodine Motors for all of their Printomatics . . .

"For over twenty years, Bodine Motors have been standard on all Fairbanks-Morse Printomatics. This precision equipment calls for a motor of small size that will stand up during years of hard usage under adverse conditions. Often operated thousands of times a day, month after month, Bodine motors continue to give satisfaction with little or no service."

Be sure your motor is as good as your product. For information contact Bodine Electric Company, 2260 West Ohio St., Chicago 12, Ill.

BODINE

fractional / horsepower

MOTORS

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Italy

A high-prestige profession in this country, the title "engineer" is highly valued as an index of professional standing, and is used on calling cards at the slightest excuse. The supply of engineers has never been great here, but a postwar surplus has developed of civil, construction, and mechanical engineers, causing many to take administrative, and public relations jobs.

However, there is a serious shortage of petroleum and electronics engineers as well as for all branches of the nuclear sciences. Italy is said to have only one nuclear biochemist, and only a dozen or so nuclear engineers doing experimental work. Exchange programs with the U. S. and England are expected to help correct this situation.

The average engineering salary is $150 a month, but with seniority up to $400 a month. Most of the important industries have their own training schools for engineers in specialized fields.

Much pirating goes on between companies, and it is reported that the State Oil and Gas Agency, ENI, in order to get its drilling teams for foreign work, has lured many of the top engineers from other companies.

France

There is now a serious engineering shortage here, especially in new industries such as electronics and nucleonics, and in industries where France is just beginning to be active, such as petroleum exploration. For the industry as a whole, a minimum of 14,000 additional engineers are needed right now. To replace those who die, retire, or leave the profession, 4,600 new engineers are required each year. But French schools are now turning out only 4,000 a year—not enough to cover replacement needs, much less add to the expanding French industry. As a result, product development and production are slowed down, and research is carried on by only a few outstanding industries.

One electronics firm now employing 1,000 engineers says that it could use 100-150 more. Another estimate for the whole electronics industry places the need at 15 to 20% more engineers for present plant and equipment. A large government-owned aircraft firm estimates that its present supply of engineers is adequate.

French companies are willing to hire U. S. engineers at roughly U. S. salaries (calculated on a cost-of-living basis), but the company must prove first that no qualified Frenchman is available. This would be easy in those fields where a severe shortage exists, such as electronics and nucleonics. But as both industries are tied up with defense work, clearance for foreigners is almost impossible.

In the aircraft industry, an engineer directing a project earns $600 to $720 a month. A young engineer on the drawing board gets $200 a month. In the electronics field, a design or project engineer earns $360 to $720 a month, depending on his qualifications and the importance of the project.

Germany

In Germany, the annual demand for engineers is 18,500; however, there are only 13,500 graduates per year. There are two types of education: the ingenieur-schule, which gives an ingenieur degree after three years of advanced training; and the technische hochschule, which after 5 to 6 years at the university gives a degree of diplom-ingenieur.

About 235,000 ingenieur and diplom-ingenieur are working in Germany at present, but another 50,000 are needed. Of the present demand for 7,000 mechanical engineers for the machine tool industry, 5,700 are needed for construction and production, and the rest for administrative work. In addition, the new German army needs 3240 engineers in all fields, and the federal post ministry needs 2200 electrical engineers.

(Continued on page 65)

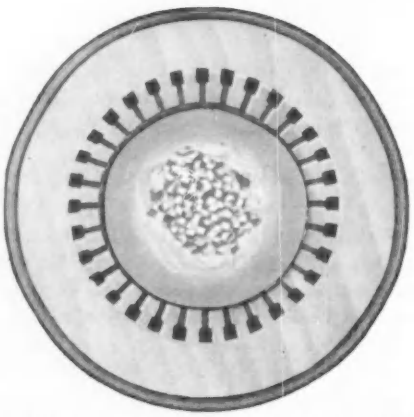
SEPTEMBER
1957

Plastiatrics

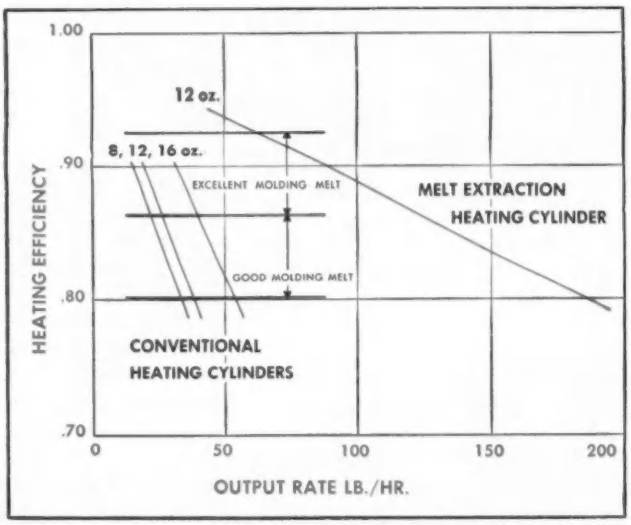
DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

DOW

PLASTIC STOCK TEMPERATURE CRITICAL FACTOR IN INJECTION MOLDING



Melt extraction heater, above, is a cylindrical device with exterior longitudinal grooves. Bottom of each groove has many perforations to provide passage to the groove. When cold plastic granules enter center of liner, they touch hot wall, melt and flow through holes to the groove and then forward to injection nozzle. Device replaces the torpedo of a conventional heating cylinder.



A melt extraction heater produces more than three times as much melted plastic at 0.8 efficiency as an average conventional heater of comparable size.

INCREASED EFFICIENCY OF MELT EXTRACTION HEATERS PROVIDES UNIFORMLY PLASTICIZED MOLDING MATERIALS

Melt extraction heating of thermoplastics shows promise of overcoming a long-recognized problem for injection molders . . . that of providing a steady flow of uniformly plasticized material to the mold cavity. The design of a melt extraction heater eliminates the need to transfer heat through the plastic. Uniform temperature distribution in the plastic is assured because the means of removing the plastic from the heated surface restricts the material removed to that which is well melted (see illustration above). When the plunger exerts pressure on the granules, the fluid polymer next to the inside surface of the liner flows through the holes into the grooves and through the nozzle to the mold.

The advantages of providing uniformly plasticized material are several. Silver streaking, caused by overheating in localized areas can be eliminated. And discoloration and brittleness of plastic parts, associated with degradation of the polymer, may be reduced with uniformly plasticized material.

The design and development of more efficient melt extraction heaters is one area now under study by Dow Plastics Technical Service engineers.

This is but one of a continuing series of Plastiatrics studies which cover every phase of plastics formulation, design, molding and finishing.

Send for Dow Technical Service bulletin entitled "Uniformity Considerations for Plastic Stock Temperature in Injection Molding" and a list of other areas under investigation. Write THE DOW CHEMICAL COMPANY, Midland, Mich., Plastics Sales Dept. 1545G.

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YOU CAN DEPEND ON DOW

Australia

There is little pirating of engineers, for like France, the German engineers have a more idealistic view of the profession, and want to remain with a company they like, rather than leave for a better salary.

Increased industrialization of this continent is making the present shortage more acute—several thousand according to engineering associations.

Just after World War II, Australia got some qualified engineers from the European pool of refugees. Today there are very few engineers among those migrating to Australia. German engineers stopped coming when that country's economy boomed. And very few Scandinavian and British engineers are arriving.

However, Australia is overcoming its shortage in the research and product development field by stepping up its imports of foreign know-how in the form of licensing agreements to manufacture foreign-developed products here. Most of these agreements, which are running at the rate of 400 a year, are being made with U. S. companies.

Pirating of engineers is widespread, and many companies have to offer special incentives to get qualified engineers. Design and project engineer's salaries range from $3300 to $8000 a year. Any number of U. S. engineers could find jobs in Australia, but at Australian wages.

Japan

Although a shortage of engineers exists here also, it would be much worse if technical training had not been intensified during the war. Japan was completely rebuilt by 1955, because of the availability of these war-trained technicians. One of the reasons for the shortage is that many engineers are being sent to Southeast Asia as a part of Japan's effort to strengthen technical and economic ties with those countries.

Shortages are particularly serious in medium and small industries. Larger companies say they have no manpower difficulties. Graduating engineers have their pick of the better paying prestige organizations; therefore, the medium and small concerns must be satisfied with relatively low-grade technicians who also are in short supply. Many of the better engineers in the small companies are over age (55), for they are automatically laid off by the larger companies if they do not make the board of directors.

Big demand is for mechanical engineers, but companies in new fields, such as synthetic fibers, petro-chemicals, atomic energy, and electronics are really feeling the pinch. The electronics situation has been aggravated by American firms hiring Japanese engineers in this field.

All firms here pay beginning engineers $28 a month, gradually increasing to about $83, the salary of the experienced engineer. Today about 30% of company administrators are engineers, and the figure is rising.

Canada

Our next door neighbor has its engineering manpower problems, and they are not helped by the raiding of Canadian firms and colleges by U. S. firms who offer considerably higher salaries. The engineering shortage has been termed alarming, forcing many companies to cut back operations.

The Engineering Institute estimates that 2700 engineers will be made available in Canada through graduation and immigration, but that total demand will be for 6000. There also is a shortage of engineers to go into Canada's hinterland. They all want to stay in the cities, particularly the college graduates. British engineers, however, have not been so reluctant, and many have emigrated to Canada for this type of work.

Engineers are the highest paid group here. In 1954, the latest year possible for income tax breakdowns, engineering and architecture commanded an average income of $12,000. —PAUL ANDERSON

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Product Engineering

September 16, 1957

the next 5 years

"How are you going to spend the next five years . . . on yourselves, or on posterity?"

A non-engineer friend asked me that in all sincerity recently, and he meant all engineers. With considerable anguish he has watched his world become so complex and specialized that only PhD's can operate it. He has a point . . . technology is moving at a prodigious pace, perhaps beyond our power to harness it for the next generation.

Do we need specialists to do the overseeing . . . to guide us through technological adolescence? We've had some pretty remarkable specialists in our corner over the last decade: Gen. Marshall and European Recovery, Mr. Eisenhower and Atoms for Peace, M. Monnet and European Federation, and Mr. Dulles and disarmament, to name a few.

But will such men of crisis always emerge in time? Scientists can be trained for basic research and development; engineers can be trained to design, make and operate products. Thus far there is no school that can train men of vision to direct the whole effort in an era hungering for higher living standards, but fearing nuclear holocaust.

Until we have enough leaders, until we learn to find and train them, all of us as individuals must contribute our bits to the general good . . . instead of "letting George do it."

The next five years may, indeed, be crucial. Some hard progress in that time must be made on such pressing problems as localized over-production, disarmament, atoms for peace, and hunger and oppression in a burgeoning world population. In every position, at whatever level, the need is for humanity and understanding, for redirection of emphasis on service instead of profit, for consideration of others before self.

What are we going to do with the next five years? Will we spend them on ourselves . . . or on posterity?

a synthetic elastomer comes of age: GERMAN auto parts use

CAST URETHANE RUBBER

. . . hard, yet elastic

R. H. KITTNER *and* **K. A. PIGOTT**
Mobay Chemical Co.

American production of this versatile abrasion-resistant material is ready to roll. This run-down on German experience since 1950 includes properties, performance features and design tips.

It's a challenge to the design engineer when the consumer asks, "Why don't they make. . . .?" For example, he has dreamed of a power lawnmowner with rotary blade hard enough to butcher grass and weeds neatly—but also elastic enough to whir fearlessly over stones and across driveway gravel without ending up looking like a haphazardly toothed gear.

Such a blade has appeared. It's made of cast urethane rubber, newcomer in a series of synthetics offered by high-polymer chemistry, and is only an experimental blade so far. But other resilient-yet-hard parts cast from the urethanes—rugged components in motorbikes and heavy farm tractors, typewriters and floor waxers—are now commonplace in Germany where the technology was developed around 1938.

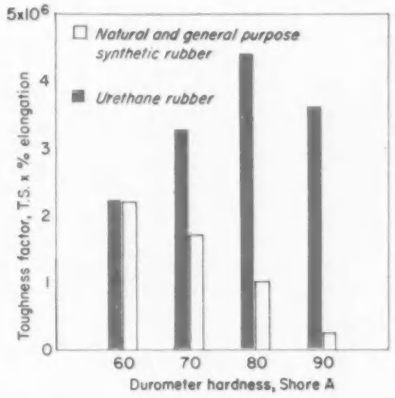
Today, cast urethane-rubber parts appear in almost every German automotive vehicle. One vehicle uses 17 different urethane parts, some of which are pictured above. This is a quick rise for a material which didn't appear commercially in post-war Germany until 1950.

American application of this unusual material is growing but must necessarily draw heavily on German experience. Presented here are considerable data, based on this background and published for the first time, that should help apply the cast urethanes to new American products.

WHAT THEY ARE

These synthetics are combinations of diisocyanates (also used in making foams) and polyesters, both in liquid form, mixed together under precise conditions of temperature and time—but at atmospheric pressure. A prepolymer is formed, and much of the curing heat common to polyester and epoxy casting resins is dissipated at this stage. This is important to the designer because it removes the major part of internal heating before the part is cast, and thin-to-heavy sections become permissible. Final step is to add a curing agent and cast the part. Curing, too, occurs at atmospheric pressure, so light and cheap molds are entirely feasible.

Casting urethane-rubber parts is not the do-it-yourself process that casting epoxy resin items can be. Consistent property reproduction requires very careful temperature control and timing of the various steps. But the reaction is sufficiently straightforward for centrifugal techniques, and equipment to do this on a pro-



Toughness factor

Stays high as hardness goes up for cast urethane, compared here with older-type rubbers. Toughness factor is product of tensile strength and elongation.

Sharp bend

in hard sheet material (Shore A durometer over 90) shows urethane rubber's big feature—hard, yet elastic. Bushing at left, for auto accelerator pedal, has slot for snap-fitting shaft, yet material is strong enough to take bearing loads.

duction basis is being developed here and abroad. The advantages are that many items can be cast in one operation, surface definition is excellent, and thin films can be cast with centrifugal force.

HOW THEY PERFORM

Most rubber materials have forced the engineer to make a choice between hardness and elasticity. Prior to the post-war growth of high-polymer chemistry, the choice was reconciled by blending waxes, plasticizers, fillers and reinforcing agents into the rubber. But blending could not give a rubber that was extremely hard and abrasion-resistant while retaining elasticity, resilience or shock-absorbing properties.

Mechanical Properties

Synthesis of urethane rubber has filled this gap. The material has a wide range of hardness, currently from 60 to 96 on the Shore A durometer scale, together with elongations from 600 to 800%. Top range for natural or synthetic rubber runs about 70 Shore A hardness and 550% elongation.

A significant way of judging rubbers is to compare their toughness factors (product of tensile strength and elongation) at various hardness levels. The higher this product the tougher, or more tear-resistant the rubber. If its factor remains high well into the higher hardness range, the rubber has strength enough for load-bearing applications such as journals, machine supports and ball joints.

In Table I the mechanical and physical properties of the two main grades of urethane rubber, *soft* and *hard*, are compared with those of natural rubber, GR-S, and Neoprene.

Rubber hardness is linked to abrasion resistance, and urethane rubbers in all hardness ranges have exceptionally good wear characteristics. Parts made from normal (soft) urethane rubber, Shore A hardness 78-83, have worn 10 times longer than such parts from the natural or synthetic rubbers. This property, coupled with a high coefficient of friction, has led to wide application in friction drives. For low-friction needs, such as oscillating journals and knuckle joint bearings, all urethane grades can be modified with additives to make them essentially self-lubricating and much higher in abrasion resistance.

Chemical Resistance

Urethane rubbers have good solvent resistance compared with natural and synthetic rubbers, but were not primarily designed for chemical resistance. They deteriorate, for example, in dilute alkalis and acids. Oil resistance is good—the only problem is the acidity or alkalinity of possible additives. This can only be resolved by test with the oils involved. Water absorption is very low, very important for close-tolerance designs like gear trains. Table II gives solvent resistance of the two grades over a wide range of chemicals.

Electrical Properties

The electrical properties of urethane rubbers are good and all grades have complete ozone and oxygen resistance. The dielectric constant ranges 6.7-7.6 at 800 cycles, with a loss factor of 0.016-0.017. Volume resistivity is in the range of $10^{10} - 10^{11}$ ohm-centimeters. The surface resistance of $10^{10} - 10^{11}$ ohms is reduced only to $10^{8} - 10^{10}$ by 24-hr water immersion.

Operating Temperatures

The harder urethane rubbers retain properties better at elevated temperatures than the softer grades, and maximum-use temperature depends on time at temperature. Because of its good oxidation resistance, urethane rubber has been used in dry air continuously at 180 F,

TABLE I—MECHANICAL AND PHYSCAL PROPERTIES OF RUBBERS

Property, (at 77F)	Soft Urethane Rubber	Hard Urethane Rubber	ASTM Natural Rubber	ASTM GR-S 1500	ASTM Neoprene Rubber
Tensile strength, psi. . .	6500	5000	3800	3900	3900
Elongation, %	725	500	440	570	470
Modulus, psi					
100%	525	1300	450	250	470
200%	700	1900	1190	610	1290
300%	1400	2900	2240	1370	2290
Elongation Set, % . . .	7	40	25	12	10
Tear Strength, lb/in. .	475	650	440	250	380
Hardness, Shore A. . . .	80	95	71	62	72
Rebound Easticity, % .	55	48	N.A.	N.A.	N.A.
Specific Gravity	1.24	1.25	1.14	1.15	1.40
Thermal Expansion x 10^{6} in./in./deg. F	110	97	37	N.A.	34
Thermal Conductivity, Btu/hr/sq ft/°F per ft.	0.133	0.133	N.A.	N.A.	N.A.

N.A.—Not available

for some days at 212 F, for several hours at 270 F, and for some minutes at 300 F. In oil, top temperature is about 270 F. Continuous use in hot water or steam is not recommended.

Stiffening at low temperatures is quite similar to conventional synthetic rubbers. Urethanes become brittle somewhere below — 90F, but can operate down to — 90 F, even though statically very stiff, if the part is flexed during operation. This is because the hysteresis characteristics are such that a very small number of flexures warms and softens it.

DESIGNING PARTS FROM URETHANE RUBBER

Size poses no particular limitations. Generally, in casting resins, large parts generate much heat in cure, then shrink considerably and often crack. Here, with exothermic heat taken off when the prepolymer is mixed, shrinkage in the finished part is small, and part size theoretically unlimited. Parts weighing up to 40 lb have been made. For hardness range 65-85 Shore A durometer, shrinkage runs about 1%; for harder grades, 2% should be allowed.

Intricate shapes containing undercuts, slots, projections and tapers are possible because the resin at pouring is water-thin. Very thin thicknesses, like typewriter-roll pads, are cast centrifugally. Adhesion to metal is very good, so a mold release like carnauba wax is required.

Urethane parts can be cast in urethane molds as long as release compound is used. Simple shapes like gears can be made by casting a urethane mold around the metal gear, stripping the mold off when cured, and casting the urethane gear in the rubber mold.

Composite castings are often made from metal-and-rubber, plastic-and-rubber, and different grades within the urethane-rubber group itself. With metal-rubber combinations, adhesion between both materials should be supplemented by mechanical reinforcement such as bosses and dovetails where possible.

Fastening urethane-rubber parts to metals or other materials can be done several ways other than by casting in place. In snap or compression fits the elasticity permits assembly and the hardness permits load-bearing in operation.

Compression load factors for urethane-rubber bushings and ball joint parts are difficult to generalize on at this stage of development. Conservative values for design are: 1500 psi for unconfined parts; 2000 psi for those with lateral restraint. To these figures should be added an appropriate safety factor. Where only occasional shock loadings occur, a stress of 2800 psi is reasonable.

For journal bearings, the hard, low-friction grade is used—but top speed is presently limited to 200 rpm. Most bushing applications have so far been oscillating motion, either rotary or reciprocal.

Close tolerance machining on rubber-metal combinations is not required because the elasticity permits small misalignments and imperfect fitting of parts not allowable in all-metal construction. Flexible couplings work with connector discs of hard urethane rubber that permit up to 0.040 in. linear and 12° angular misalignment without malfunction.

Gears of urethane rubber, being made for such products as floor waxers, kitchen mixers and motorcycle chain-drive sprockets, are always mated against metal gears and manufactured from the harder urethane grades. Greater misalignment and looser tolerances can be tolerated in these combinations because of elastic action, and dirt will pass through the train without damage. The elastic tooth of a rubber gear, however, undergoes different motion from that of a rigid tooth—instead of touching the counter-surface in a line, the elastic tooth forms its own contact surface.

Both maximum load and torque transmission depend on the peripheral velocity and dimetral pitch of the gear. Experience with urethane gears shows that the basic relations for steel and other materials are valid here. The chart (opposite page) shows tentative load-

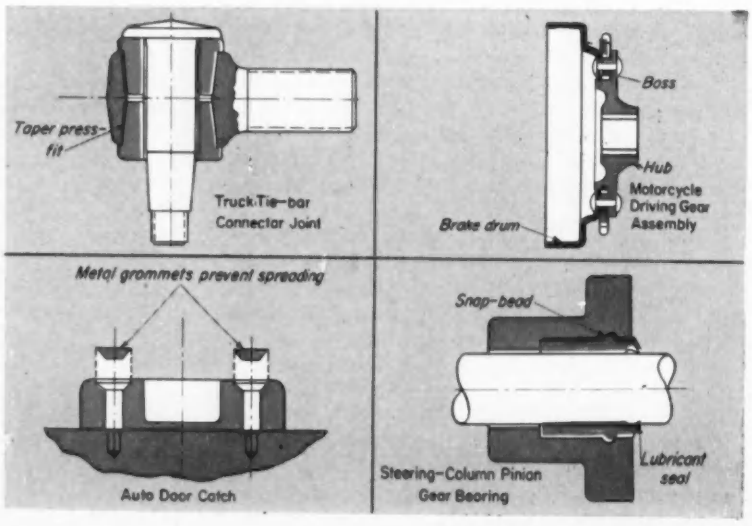
TABLE II—SOLVENT RESISTANCE OF URETHANE RUBBERS

Room-temperature Swelling, %

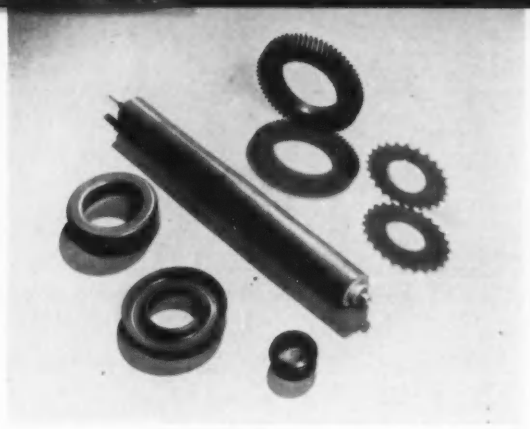
Solvent	Soft	Hard
Water	1.5	1.5
Mineral Oil	1.5	0.5
Mineral Spirits	2	2
Alcohol	15	8
Xylene	20	17
Toluene	37	25
Carbon Tetrachloride	44	33
Ethyl Acetate	70	50
Nitrobenzene	165	85
Methylene Chloride	310	165

Urethane rubber and metal parts . . .

can be fastened together without embedding. Here are four ways.



METHODS OF CASTING PARTS . . . AND USES FOR THEM



Centrifugally cast parts . . .

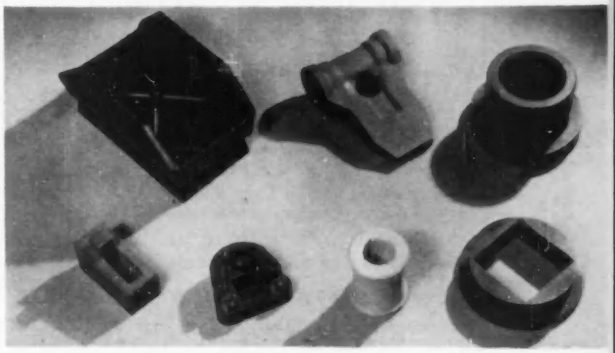
include thin pad on aluminum typewriter roller, center. Above it are spiral gear and motorbike chain-drive sprocket; below, clamping-ring support for motor ball bearing, packing ring, and oil-seal bushing for auto steering-column pinion gear.

Composite casting . . .

meets unusual requirements by teaming different urethanes. From left: Bumper block for weaving machine has high-density sponge urethane between hard faces; propeller-shaft bushing and oil-pipeline flange gasket have soft core reinforced by hard outer ring.

Abrasion resistance . . .

is required of these urethane parts. From left: adjustable sand-blast nozzle, motorbike sprocket gear, spring-and-shoe (top) for chain tightening, pump rotor, reinforced timing belt for tape recorder, leaf-spring shoe and motorbike drive wheel.



Hardness plus resilience . . .

is common to all these parts. Top row, from left: Truck leaf-spring shoe, textile shuttle driving hammer, spring-shackle bushing, another shuttle hammer, auto door catch, press-fit bushing for tie-rod, and bearing for railroad turntable.

factor curves giving the load limit for urethane-rubber gears running in oil. The C-factor is defined,

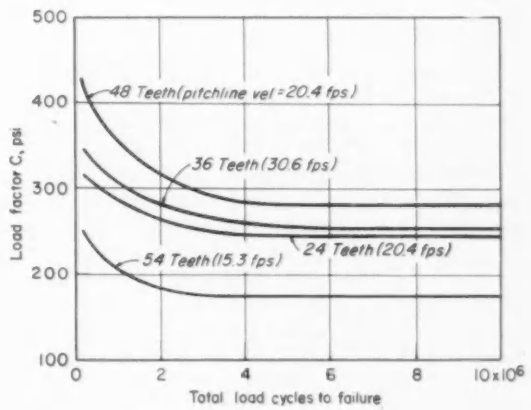
$$C = \frac{F\,n}{\pi\,b\,d}$$

where
C = load factor, psi
F = peripheral force, lb
b = tooth width, in.
d = pitch diameter, in.
n = number of teeth

Variation in gear-train dimensions because of moisture absorption, a difficulty with nylon gears, can be neglected because water absorption by urethane rubber is very low. It is recommended that urethane gears be operated with oil lubrication for at least one month to diminish chances of swelling by moisture.

EDITOR'S NOTE: Urethane rubber parts are currently engineered and manufactured by the following firms in this country: Acushnet Process Co., New Bedford, Mass.; Armstrong Cork Co., Lancaster, Pa.; Dayton Rubber Co., Dayton, Ohio; Disogrin Industries, Inc., Jamaica 30, N. Y.; Ohio Rubber Co., Willoughby, Ohio; Trostel Packings, Ltd., Lake Geneva, Wis.; General Tire and Rubber, Akron, O.

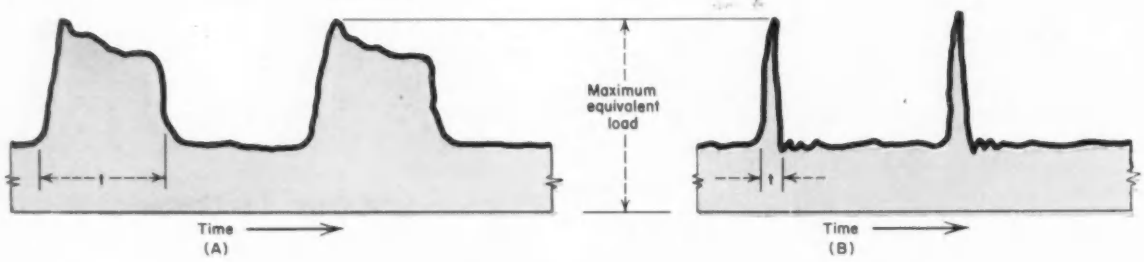
A recent article, "Epoxy Castings," June '57, p 135, covers cast-in-place plastics as alternatives to metal or molded plastics.



Load curves . . .

for urethane rubber gears against steel gears. Several gears are run at same speed but with different loads until the gear breaks. Load factor is then plotted against number of revolutions (or loadings) to failure, forming a limiting load curve. Tests are repeated for different sets of gear dimensions. Here gears are 20 mm wide, have a modulus of 3 mm, and run in oil.

how to reduce



. . . SHOCK LOADS IN BEARINGS

1 Degree of shock in a bearing depends on both magnitude and duration of the load. Bearing in (A) may have rotated several times during time *t*, thus avoiding a brinelling action. Short duration in (B) may be equivalent to impact, drastically reducing life.

R. H. CARTER, *Chief Engineer, Miniature Precision Bearings, Inc.*

Equations and tables for estimating shock capacity of bearings; special races, springs, resilient materials, preloaded bearings and floating units to reduce shock.

Proper design can reduce or eliminate the severe shock loads which frequently cause bearing failures in applications ranging from small instruments to large machine tools. In fact, failure from shock is more common in small bearings than fatigue failure, because the number of stress cycles necessary to cause fatigue (induced by the rotating balls) is far beyond service life of the unit.

Shock loads are of short duration, causing damage only when a bearing is stationary, rotating slowly, oscillating over a small angular arc, or subjected to vibrations. Shock loads can rapidly cause permanent deformation of the balls or raceways, or even fracture.

Shock may occur from operating conditions, such as impact, acceleration and deceleration; or from unexpected factors, such as improper handling and assembly, chatter in machining, and sudden fracture of machine parts causing an instantaneous build-up of forces. Magnitude of the shock loads is difficult to compute, or even predict; the modern trend is to incorporate a method or device for reducing shock (Table I) whenever conditions warrant.

Duration of the load is very important, Fig. 1. If the shock load is of short duration and the bearing rotates several times during its imposition, as in (A), any deformation that may occur in the ball race will be spread out to form a track, thus avoiding brinelling. With such loads, it may even be permissible to exceed the static capacity of the bearing. However, if the overload is a definite shock or impact, as in (B), brinelling may occur, thus drastically reducing life.

HOW MUCH SHOCK CAN A BEARING WITHSTAND?

It is difficult to predict the type of shock load that may occur, and there are no ratings for shock capacity of a bearing. Magnitude and duration of the shock load are involved in addition to bearing geometry. However, as the ability of a bearing to withstand shock is related to its static capacity, a rough estimate can be made on this basis.

Static capacity is the load that a bearing can withstand when stationary, without the magnitude of permanent deformation that may occur in ball or race exceeding 10^{-4} times the ball diameter. Thus, by eliminating speed from the analysis, the following formula has been empirically developed to determine the static capacity C_o of a radial ball bearing:

$$C_o = f\, z\, i\, D^2 \cos \alpha$$

where i is the number of rows of balls in the bearing, z is the number of balls in each row, D is the ball diameter, angle α is the contact angle and f is a constant depending upon type, Table II.

A bearing can withstand greater loads than the static capacity, providing the load has a sufficient duration, Fig. 1(A). Dynamic capacity C of a bearing is usually one and a half to two times the static capacity. Table III compares the static and dynamic capacities of miniature ball bearings (0.3125-in. OD, 0.0937-in. bore, except the thrust bearing which has a bore of 0.1250 in.)

Maximum permissible load, whether momentary or

Table 1—Methods of Reducing Shock Loads in Bearings

Method	Where to Use	Advantages	Limitations	Effect on Bearing Life	Relative Cost
Special Races, Fig. 2	Cam followers Guide rollers Pulleys Index pawls	Minimizes distortion Lessens danger of fracture resulting from impact Supports more exterior loads	Increases space requirement May not be available as a standard	Extends unit life Minimizes maintenance	Somewhat higher initial cost Lower operating costs
Cushioning (A) Springs, Fig. 3 (A and B)	Potentiometers Indicator vanes Slightly pre-loaded devices	Absorbs some shock Provides axial control of shaft location by reducing clearances and allows for temperature expansion	Requires additional components, such as springs Increased space needed for spring to operate	Improves unit accuracy Prevents damage to unit under severe shock loads Extends unit life	Normal bearing cost Additional cost due to purchase, handling, assembly and inspection of springs
Rubber rings Fig. 3(D)	Gear trains Motors Slightly pre-loaded devices	Reduces noise Less space than most springs Absorbs shock axially only Provides axial control of shaft	Limited standard sizes and Elasticity may be available Deterioration possible from some oils, chemicals	Unit life is extended Prevents damage to unit from shock or vibration	Normal bearing cost Additional cost is in rings and assembly but may be less than springs
Rubber mount, Fig. 3(E)	Motors Planetary gears Rod ends	Absorbs shock in all directions Minimizes outer distortion Cuts noise level beyond that above	Increases space requirement Complicates unit assembly Deterioration possible from some oils, chemicals	Vibration is damped Prevents damage to unit Under severe shock loads Extends unit life	Normal bearing cost Additional cost is in material and assembly
Preloading Spacers	Gyro rotors Precision spindles Gear trains	Reduces deflections under load Maintains positive location Maintains preload as positive value Reduces axial shift under high acceleration	Additional components increase inspection and assembly costs Increases space requirement	More uniform performance Permits high speed with combined loads Extends unit life	Normal bearing cost, unless manufacturer supplies complete package Complete package slightly less than duplex pairs
Duplexing (1) Back-to-back	Same as above	Increases stiffness of system Establishes fixed contact angle or ball path	Increases identification problem in stock room Increases space requirement	Method offers best solution for most applications of this type	High bearing cost must be offset by advantages gained in use and assembly
(2) Face-to-face	Same as above	Same as above but offers same degree of self aligning	Stiffness slightly less than DB mounting because of convergent contact angles	Same as above	Same as above
(3) Tandem	Same as above	Provides additional thrust-load capacity in one direction Provides accurate axial location for shaft	Must be opposed by single or double bearing to provide preload	Used only for specific applications to extend unit life beyond normal single-bearing performance	Same as above
(4) DU mounting	Same as above	Can be used universally as DB, DF or DT mounting—or mounted at random for a duplex pair Identification of matching faces not necessary	Additional cost involved if only one mounting method required	Serves as general-purpose duplex bearing	Approximately double cost of pair of either DB, DF or DT bearings
Flotation	Gyro packages Accelerometers	Absorbs shock, dampens noise Reduces effective mass of supported member Reduces deflections caused by outside forces	Increase in package size More complicated assembly procedure required	Added safeguard to be applied to all above units if conditions warrant	Cost of bearing remains same Additional cost in unit assembly and material

TABLE II
Load Constants for Various Bearing Types

Bearing Type	f	
	Kg-mm	lb-in.
High Speed (Magneto)	0.30	427
Self aligning	0.34	484
Groove	1.25	1780
Angular contact	1.25	1780
Thrust	5.0	7100

TABLE III
Comparison of Static and Dynamic Capacities of Miniature Ball Bearings

Bearing Type	Static Capacity C_o, lb	Dynamic Capacity C, lb
Radial	69.4	103
Radial Retainer	41.6	76
High Speed (Magneto)	46.2	83
Thrust	221.0	190

TABLE IV—Relationship Between Permissible Bearing Load P and Static Capacity C_o for Various Conditions.

Condition	Relationship
To cause actual fracture	$P = 8\ C_o$
For steady loads	$P = 2\ C_o$
For steady loads with some shock	$P = C_o$
For smooth performance under shock loads	$P = \frac{1}{2}\ C_o$

constant and steady, depends upon the required conditions of operation. Although a bearing can withstand dead loads up to eight times the static capacity without fracturing, tests have indicated that, to be on the safe side, maximum equivalent radial load should not exceed twice the static capacity, even if the bearing is expected to operate free of shock. For ordinary service and to accommodate some shock, the maximum equivalent radial load should not be much greater than the static capacity. However, for operations involving high requirements or sudden shocks, the maximum equivalent radial load should not exceed half the static capacity of the bearing, Table IV.

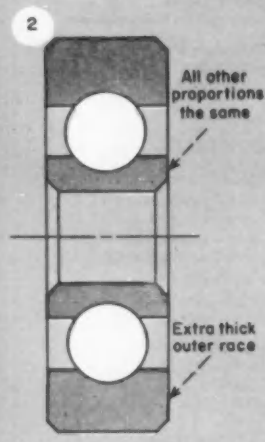
DESIGNING FOR SHOCK CONDITIONS

After a bearing is selected of static capacity within the range of expected shock, performance can be improved various ways: for example, using a special, extra-thick outer ring to sustain continuous radial impact, Fig. 2. This ring wall will prevent premature fracture and lessen outer-race distortion, but will not necessarily add to capacity. Therefore, unless interior geometry is also modified, this bearing will perform no better than a standard one except where resistance to fracture, rather than smooth operation, is the primary service criterion.

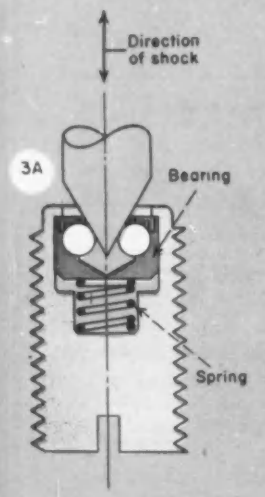
Two basic methods protect the bearing from shock. One minimizes effect of the shock; the other prevents it from reaching the bearing and associated components.

Minimizing shock effect is primarily a matter of mounting. If the expected shock loading is in one direction, the effect can be minimized by mounting the unit so the loading is in the direction of the shaft axis, and impact is taken axially (in thrust) with all balls sharing the load. In other words, it may be best to mount the unit at an angle.

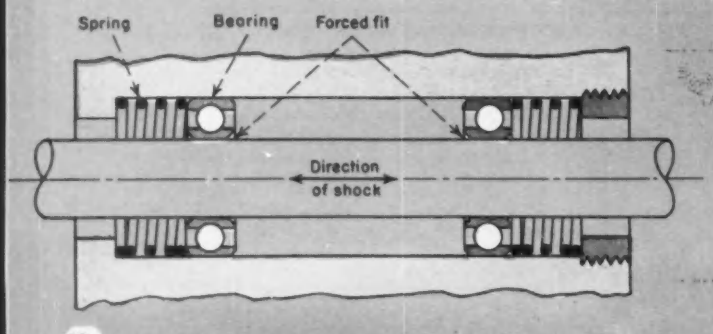
Cushioning or preloading minimizes shock effects, because the bearing would tend to move as a single mass with adjacent components. Four methods of shock mounting are illustrated in Fig. 3, in which an elastic member absorbs the energy of shock to reduce impact between bearing and housing. Both springs and resilient materials can be used. In (A) the spring provides both shock resistance and proper cone pressure for a pivot bearing. In (B) the springs prevent bearing damage from axial shock loads in either direction.

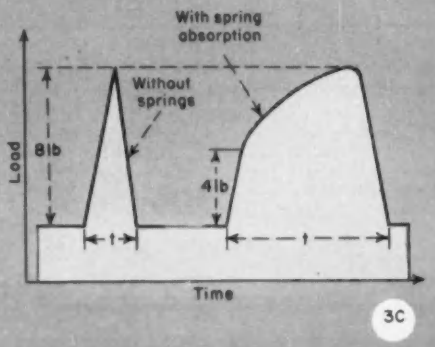


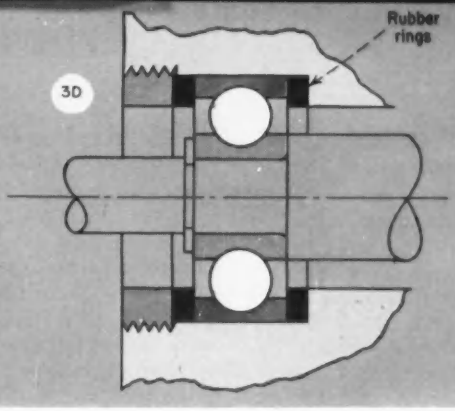
2 Specially designed bearing has extra-thick outer race to sustain radial shock loads.

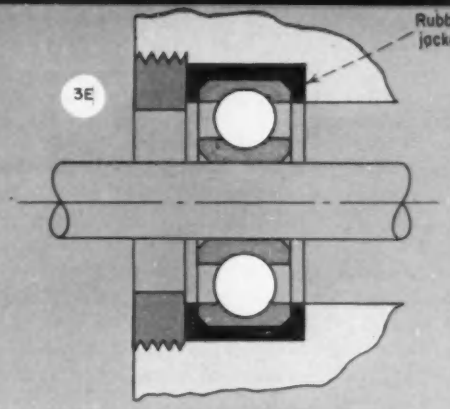


3 Methods for reducing shock loads on bearings. Preloaded springs in (A) and (B) extend time duration of shock load, as shown in (C). Rings and jackets, (D) and (E), made of resilient material, reduce noise as well as shock loads.









Spring stiffness depends upon the degree of shock expected. If bearing capacity is 8 lb and a shock load of 8 lb is anticipated, the spring is designed so it exerts a force of 4 lb, as in (C). Thus the bearing floats against the spring, and the duration of impact is extended. However, natural frequency of the system must be checked against the operating frequency to avoid resonance.

Two rings of resilient material can be used in place of springs, as in (D), to absorb any shock transmitted from the shaft before the balls brinell the outer race. In (E), a rubber jacket provides shock absorption in all directions. This is becoming standard practice in design of air-conditioning and heating equipment to reduce noise and vibration. As with springs, thickness and elasticity of the jacket must be specifically selected to meet operating requirements.

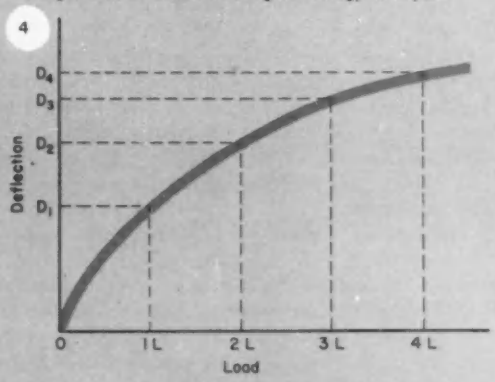
PRELOADING REDUCES SHOCK EFFECTS

Preloading the bearing removes any axial or radial play. This in turn keeps the bearing in tight mesh with the shaft and housing, thus reducing shock effects.

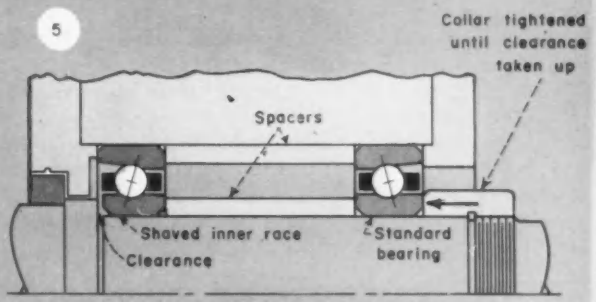
Increased preloading reduces the deflection rate of a ball bearing. Each successive increment of load results in a decreasing yield, Fig. 4. Therefore the deformation, or yield, resulting from a given shock load will decrease as the preload on the bearing is increased, thus reducing the energy of impact. For example, a bearing which is not preloaded will deflect an amount D_1 under the imposition of a 1-lb shock load. However, a bearing operating under a 3-lb preload will only deflect an amount $(D_4 - D_3)$ under addition of a 1-lb load.

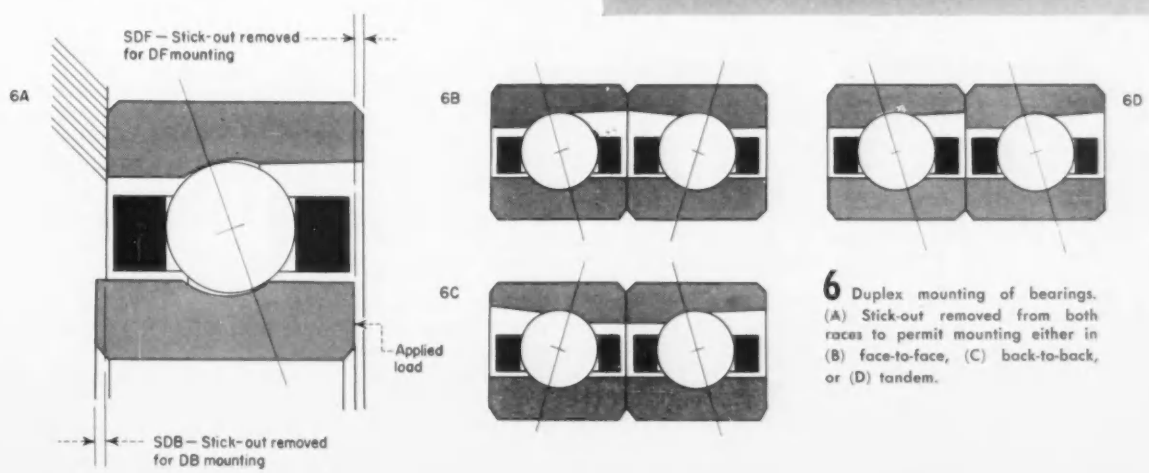
Each bearing has a specific load-deflection charac-

4 Load-deflection curve of a ball bearing showing advantages of preloading with respect to shock. If bearing is preloaded to D_3, an additional load of L will only cause a slight deflection, thus reducing the energy of impact. ▼



5 Bearings can be preloaded by grinding the bottom race of one bearing to reduce width. Preload is applied through two equal-length spacers by tightening threaded collar. ▼





6 Duplex mounting of bearings. (A) Stick-out removed from both races to permit mounting either in (B) face-to-face, (C) back-to-back, or (D) tandem.

teristic. At some point, the curve begins to flatten and deflections decrease rapidly for each additional load. It is advantageous to preload the bearing close to this point of the curve. However, torque increases with preload and if the break occurs too high for the application, another bearing should be chosen. Such curves can usually be obtained from the manufacturer and are invaluable.

There is no reduction in bearing life if preload is much smaller than operating load. In fact, the bearing will operate smoothly for a longer period than a non-preloaded bearing.

METHODS OF PRELOADING

Preloading is usually accomplished by matching pairs of bearings (generally referred to as "duplexing") and applying the preload axially to either the inner or outer race. The amount that the face of the loaded race protrudes after loading is measured, then removed by grinding or lapping. This results in a 'stick-out' of the unmodified race, unloaded, equivalent to the displacement under preload. In final assembly, the two ground faces are forcibly clamped together, or as in Fig. 5, only one bearing is ground when using spacers of equal width.

In another method of preloading, the stick-out is removed from both races, Fig. 6, and applied in both directions axially. This results in a pair which can be mounted either face-to-face (DF), back-to-back (DB), or in tandem (DT) with the same preload. Axial separation of the duplexed pair can be accomplished by mounting spacers of equal width between both inner and outer rings. The bearings can be purchased as 'special' with the stick-out ground off. Generally, the user specifies the amount of preloading desired and leaves it to the bearing manufacturer to determine the amount of lip to remove. Some larger bearings used for preloading are carried as stock items.

Preload may also be accomplished by grinding an amount equal to the measured stick-out from the spacers instead of the bearing faces. This method can also be used to change the amount of preload on any duplexed pair.

The mounting arrangement for a duplexed pair has great influence on resultant stiffness and permissible misalignment of the assembly. Mountings in which contact angles of the two bearings converge externally give maximum stiffness and least permissible misalignment. Internally convergent contact angles provide maximum permissible misalignment at the expense of stiffness. As stiffness of mounting minimizes the effect of shock, back-to-back duplexing (DB) is preferable.

When required preload is slight, the amount of axial yield resulting from preloading—after removal of play within the bearings—becomes less than the manufacturing tolerances on face-to-face run-out. Preload then may vary in the installation from its intended value because the measured stick-out will depend upon the orientation of the bearing races during measurement and will differ when the bearings are clamped together. This could result in unsatisfactory performance. It may be best, as in Fig. 3(B), to spring-load the bearings to remove axial and radial play and at the same time increase stiffness.

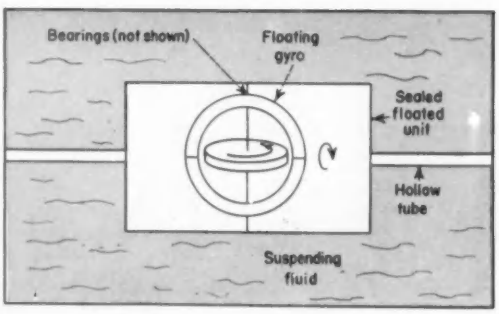
PREVENTING SHOCK LOADING

Probably the ultimate solution to the problem of shock or impact loading is to prevent the overload imposed upon the mechanism from reaching the bearings at all. This approach calls for completely isolating the bearing and components associated with it and is used in critical applications where extreme shock loads are expected.

Most common method is to float the entire unit in an appropriate fluid to reduce its effective weight greatly. Thus, accelerations from sudden overloading of the parent assembly, although transmitted to the bearing-equipped unit, impose little force or load upon it.

The electro-mechanical unit in Fig. 7 operates in a sealed container floated in fluid in a larger container. Hollow tubes retain the unit and provide access for electrical leads from the outside to the unit. Silicone fluids are commonly used as the supporting media because of their almost-constant viscosity index, which remains stable throughout wide variations in temperature.

This method, however, does not preclude shock-mounting the bearings of a gyro. In fact, a combination of methods is usually employed in critical applications where reliability is the prime requisite.



7 Gyro unit floated to reduce effective weight and isolate it from shock. Wires to power the electric motor or gyro are passed through hollow tubes. Floating reduces response to acceleration. Component of shock perpendicular to tubes is eliminated; shock in direction parallel to tubes is damped by the fluid.

EDITOR'S NOTE: In addition to the specialized methods used for bearings, shock effects can be reduced by mounting the unit on vibration isolators. A new method of analyzing the performance of viscoelastic materials, such as rubber, nylon, rayon, and fibrous materials is discussed in "How to Predict Performance of Rubber Vibration Isolation," July 1957 page 141.

For other significant articles on vibration isolation, see Editor's Note on page 145, July 1957. For analyses of other phases of shock and vibration problems, see these recent articles:

"Chatter in Gear Drives," December 1956 page 169. How to measure gear chatter; equations for computing speed variations and eccentricity.

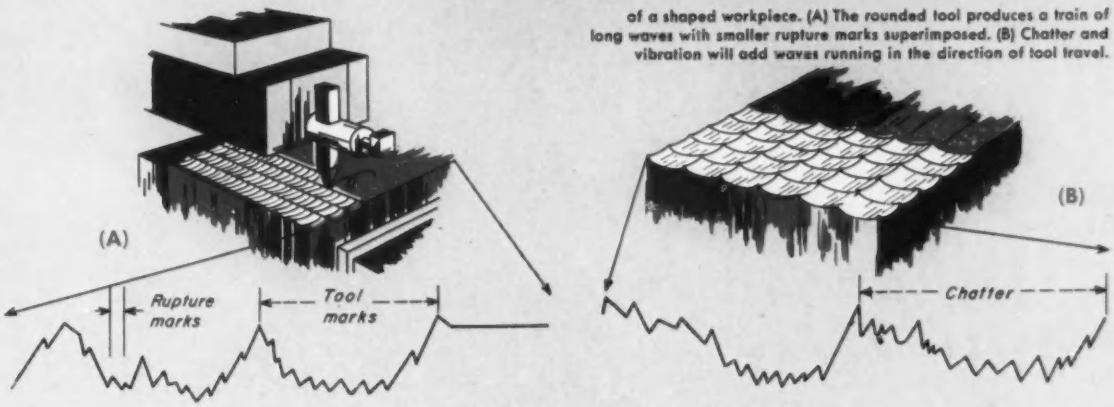
"Designing Beams for Shock and Vibration," November 1956 page 221. Method and nomograph for determining the natural frequency of ten different types of beams.

"Random Motion," November 1956 page 169. New concept for defining, measuring and reproducing random motion on equipment.

"Elimination of Impact Forces at Pivots," March 1955 page 205. Weights shift the center of percussion away from pivots.

1 Two surface characteristics . . .

of a shaped workpiece. (A) The rounded tool produces a train of long waves with smaller rupture marks superimposed. (B) Chatter and vibration will add waves running in the direction of tool travel.



SURFACE FINISH

• what it is

• how it is measured

R. E. REASON, *Head of Electronic Industrial Research, Taylor, Taylor and Hobson Ltd.,* Leicester, England*

"What surface finish shall I specify?" This question comes up with increasing frequency. Here are some quick answers, including characteristics of manufactured surfaces, instrumentation, meter operations, and the separation of roughness and waviness by electrical wave filters.

Most surfaces found in nature are characterized by irregularity. The earth's surface slopes and dips, climbs and falls in irregularities as high as the Alps or as shallow as the difference between the crest of an ocean wave and its following trough. Yet a mean surface may be imagined that considers the earth essentially spherical in shape or, more accurately, an oblate spheroid.

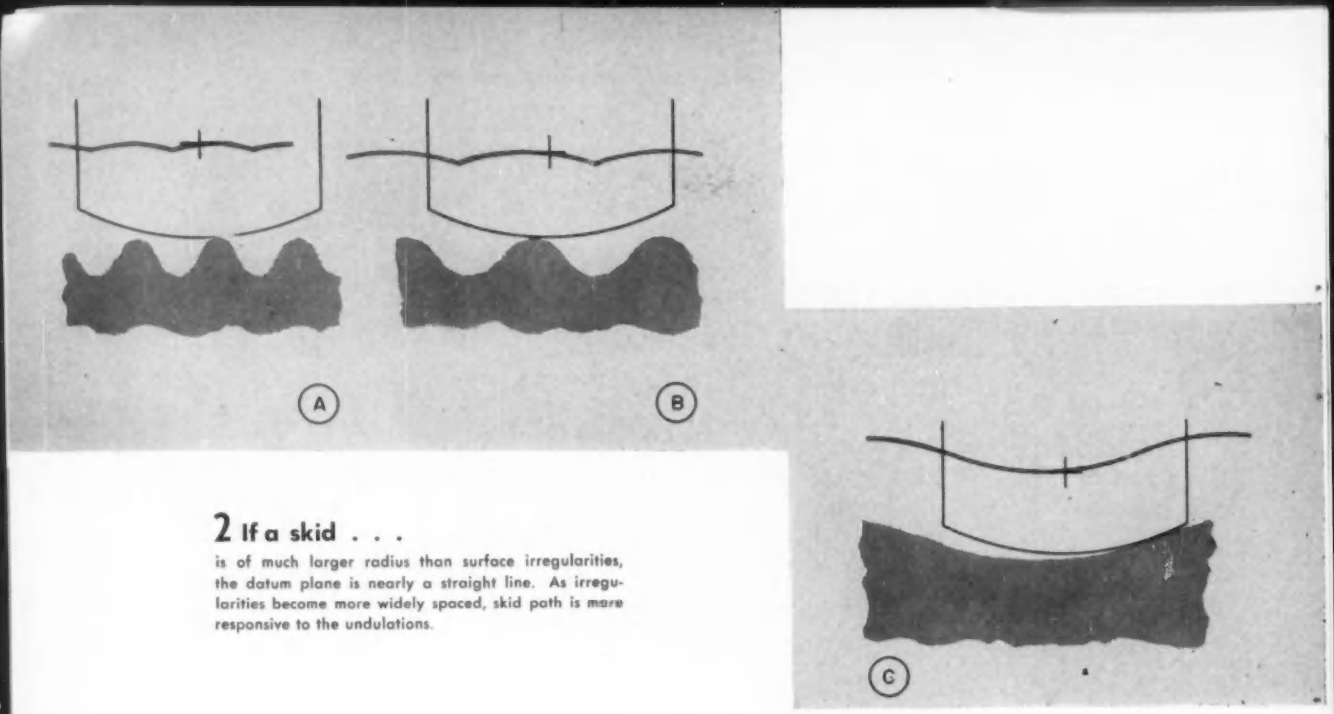
By analogy, the topography of most manufactured surfaces, no matter how small, is likewise characterized by peaks and valleys of varying height and spacing, and a mean surface can be found that can be considered the essential shape or form of the object.

Irregularities making up this surface can often be seen as two or more distinct series of "waves" of different spacing. (While the recurrence of what the eye sees as waves is often not strictly periodic, a sufficient approximation to periodicity can often be found for purposes of analysis.)

On any surface produced by a particular machining method, the smallest irregularities, which in size may go down to molecular heights and width, are generally caused by the way metal has been torn away by the tool. They are generally superimposed on irregularities larger in both height and width, caused by the shape of the cutting element. With single-point cutting processes, exemplified in Fig. 1(A), a rounded shaping tool produces a regularly spaced shallow groove in the work surface each time it makes a pass. This scalloped pattern over the entire surface is characteristic of the shaped surface. Abrasive processes add fine scratch marks, quite irregular in shape and spacing, and having rupture marks.

Tool chatter and vibration may give rise to even more hills and valleys. These wave trains, viewed in the direction of tool traverse, would be of longer wave length than the basic tool or scratch marks, and gener-

* *Taylor, Taylor & Hobson Ltd. is represented in the U. S. by Engis Equipment Co., Chicago, Ill.*



2 If a skid . . .

is of much larger radius than surface irregularities, the datum plane is nearly a straight line. As irregularities become more widely spaced, skid path is more responsive to the undulations.

ally periodic: From this it is seen that the term "waviness" is well chosen.

A fourth kind of irregularity can result from errors in the machine ways. As the tool takes its cut it wanders gradually from true course, leading to error in the form of the work surface. This type of error might also be caused by deflection of the work under the cutting load, or by distortion resulting from localized heating.

DISTORTION IN RECORDING

The height of irregularities is generally very small compared with their width. For example, crest spacing of a planed surface may be an inch and of a lapped surface only a few thousandths of an inch. Crest heights will only be a few thousandths when planed and perhaps a few millionths when lapped.

A graphical representation of reasonable size, able to show successive changes in height of a representative length of the surface, therefore enforces far greater magnification in the vertical than in the horizontal direction.

This means, for the sake of visibility, the slopes of irregularities are grossly exaggerated. Deep valleys and sharp spikes on a graph are rarely more than a few degrees in slope and often no more than a fraction of a degree.

No one method of measuring surface irregularities covers perfectly the whole range met in manufacture. The technique must be determined by height and crest spacing. Optical-interference methods probably give the most nearly perfect picture of the very finest surfaces, and optical-shadow methods will do for coarser ones of moderate crest spacing; but without recourse to much trouble these methods provide neither permanent record nor numerical indication.

Probably the stylus method comes nearest to being universal. A sharply pointed stylus traces across the work; and an electric signal, generated by vertical stylus oscillations, drives a recorder or is averaged and indicated on a meter.

Rounded skids, fixed with respect to the pickup body and sliding on the surface near the moving stylus, can provide a datum against which stylus motions are measured. This is generally adequate if crests are close enough together for the skid to ride over without sinking appreciably into the troughs.

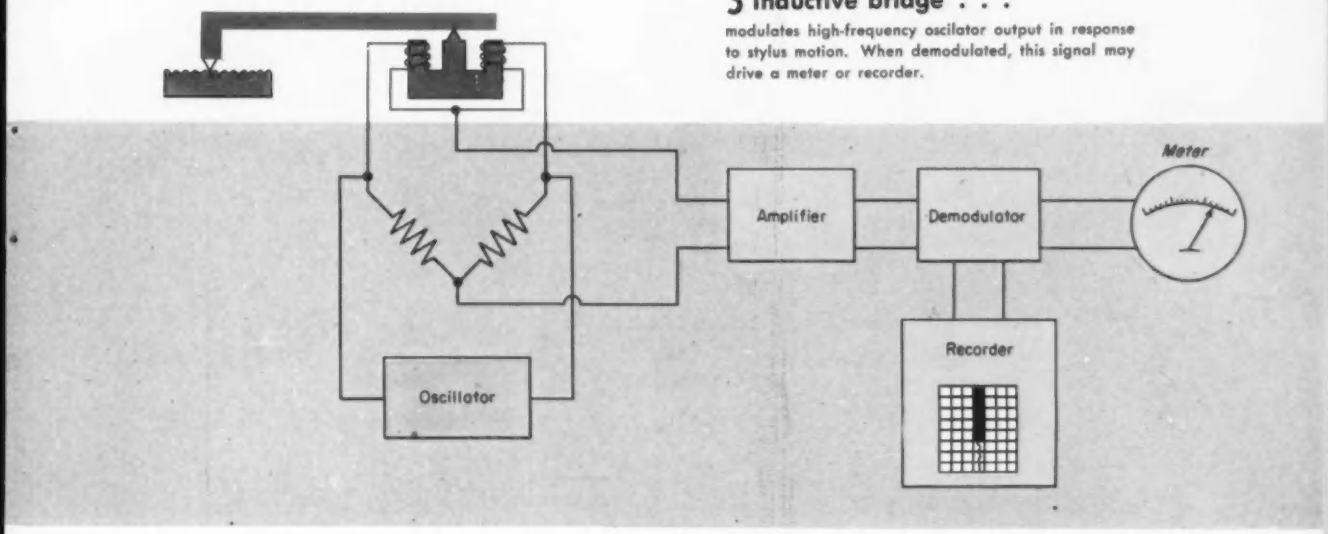
The shape of the datum is the locus of its center of curvature. Fig. 2A shows crests close together, and the datum substantially straight; in *B* the datum is becoming distinctly deformed; in C spacing is so great that the datum has substantially the shape of the surface itself. However, the skid does not touch the surface at the same point as the stylus—the stylus may be going up while the skid goes down. A useful representation of the surface may therefore be had even though the skid is going up and down as much as the stylus.

PICKUPS

There are various ways to convert stylus movements into an electrical potential or current for operating a recorder or integrating instrument.

The system in Fig. 3 has the stylus mounted on the end of an armature which, when tilted, varies differentially the air gaps of two inductances, one on each side of the pivot. Inductances are connected in a bridge circuit fed from an oscillator supplying carrier current. Output varies in proportion to armature inclination. Carrier-current frequency is high relative to the speed with which the stylus moves up and down. The modulated carrier is amplified, demodulated to extract the wanted signals and then fed to a pen recorder. The advantage is that every stylus movement, however slow, can be reproduced. These roughness signals can also be fed to an averaging meter.

Another device has a stylus-driven coil moving through a magnetic field, Fig. 4. The coil generates cur-



3 Inductive bridge . . .
modulates high-frequency oscilator output in response to stylus motion. When demodulated, this signal may drive a meter or recorder.

rent proportional to its velocity. A correcting circuit makes the output dependent only on amplitude, and is arranged to work only for frequencies above a certain value, called the cutoff. For lower frequencies, representing waviness, there is little or no output. The method is not used for recording but is very suitable for average movements.

Piezoelectric devices flex a piece of Rochelle salt or barium titanate (Fig. 5) to produce an electrical potential proportional to strain in the material. After amplification this signal can operate electrical recording and integrating instruments. Crystals tend to behave rather like a moving coil, because although in theory the electrical potential should last as long as the crystal is strained, in practice the minute electric charge quickly leaks away. These devices are not ideal for making records because slow up-and-down movements of the stylus may not generate voltages exactly proportional to the displacement.

A transducer tube (RCA 5734) is a more recently developed tool. Here, one of the electrodes is displaceable through a diaphragm to vary the anode current proportionally. The working range is rather short, but the problem—coupling the tube to a stylus with the relatively large free range of movement required in a manually operated pickup—has been neatly solved by viscous coupling.

The modulated-carrier system has the equivalent of a rigid lever (Fig. 6A) magnifying the stylus movements. Imagine the lever as so light that it can magnify with a ratio of 100,000:1 though the operating force is only a few milligrams. Moving coil and piezoelectric devices are equivalent to a lever maintained in a mean position by a spring and displaced by the stylus acting through a dashpot filled with oil (B). When up-and-down movements are fast enough, the oil acts as a rigid coupling between stylus and lever, and the behavior is exactly like that of the simple lever; but when movements are slow the oil has time to leak past the piston in the dashpot, and the pointer may not move in proportion to the movement of the stylus.

The average departure from a mean line has been the most widely used method of rating roughness height. But there are also adherents for methods of assessment from peak to valley (DIN 4762/52), from an average peak line to an average valley line (Swedish Standard), and as an average depth below a crest line (DIN 4762/52, 4760/56, 4762/56). All have their good and bad points. All would sort a collection of rough and smooth surfaces in approximately the same order. An important virtue of the mean or center-line method is that, lining up with the natural mode of behavior of simple electrical circuits, it has favored the evolution of practical, direct-reading workshop instruments.

Because roughness includes the primary feed marks of a single-point cutting process (marks with fundamental spacing equal to traverse feed of the tool), the spacing to be taken into account in measuring roughness height can vary through a wide range: from a few thousandths of an inch in diamond turning, to a few tenths in shaping and planing. Correspondingly, the crest spacing of the associated waviness can vary from a few hundredths of an inch to a few inches.

CUTOFF

With electrical instruments measuring from the mean line, roughness is conveniently separated from waviness by an electrical wave-filter with a transmission characteristic of the general type shown by curve A in Fig. 7. These filters transmit or reject signals according to frequency. They are made to control the roughness-width cutoff by proper choice of cutoff frequency in relation to speed of traverse, according to the simple relationship: Frequency equals trace speed divided by crest spacing. For example, chosen trace speed is 1 in./sec and the filter should transmit tool marks spaced up to 0.03 in., but reject undulations more widely spaced.

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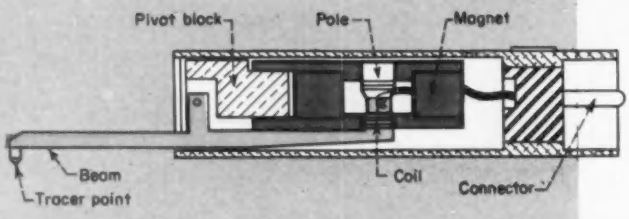
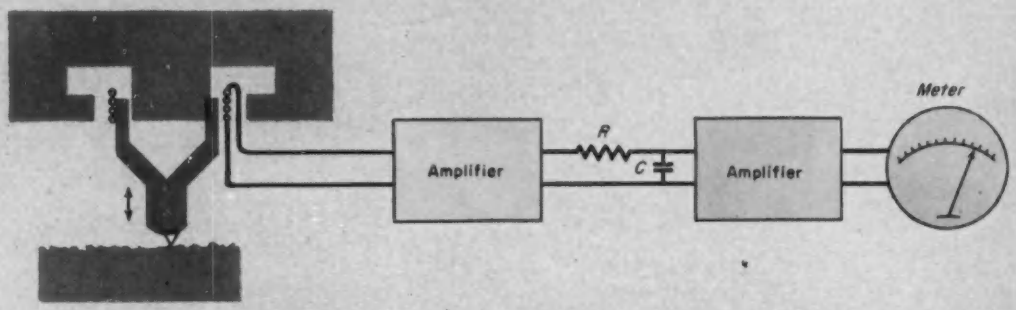


4 Moving coil . . .

in a magnetic field generates a voltage proportional to stylus speed. The R-C integrating network supplies displacement signal to amplifier and meter. Shown also is cross-section through an actual tracer head manufactured by Micrometrical Manufacturing Co.



The filter should cut at a frequency of 33 cycles/sec. To cover the range of crest spacings found on surfaces of all sizes, without too many changes in the roughness-width cut-off, the series 0.003, 0.01, 0.03, 0.1, 0.3 in. has been standardized.

Of this series, the value 0.03 in. works for so wide a range of the finer finishes that it is sometimes nominated as *the* standard, and regarded as the only dividing line between roughness and waviness. But this is inconsistent with the definitions in B46.1-1955, and would lead to a number of difficulties. For example, if the traverse feed of a lathe were changed from 0.028 in. to 0.032 in., there would be no significant change in the nature, appearance or quality of the surface, but it would be necessary to say that while in the former case the surface had a certain degree of roughness, in the latter it had no roughness but a certain degree of waviness —a change in designation that would hardly be helpful. Again, on a fine-pitched diamond-turned surface, true waviness could itself have a spacing of less than 0.03 in. The division between roughness and waviness must be allowed to vary according to the roughness width found on the surface.

Transition from full to negligible response of an electric filter does not occur abruptly but is spread over a range of wavelengths. In B46.1-1955, the effective cutoff wavelength is taken as that for which there is 70% transmission. The roughness filter should attenuate the waviness enough to prevent it from influencing the roughness reading, without introducing excessive phase distortion in the roughness pass band.

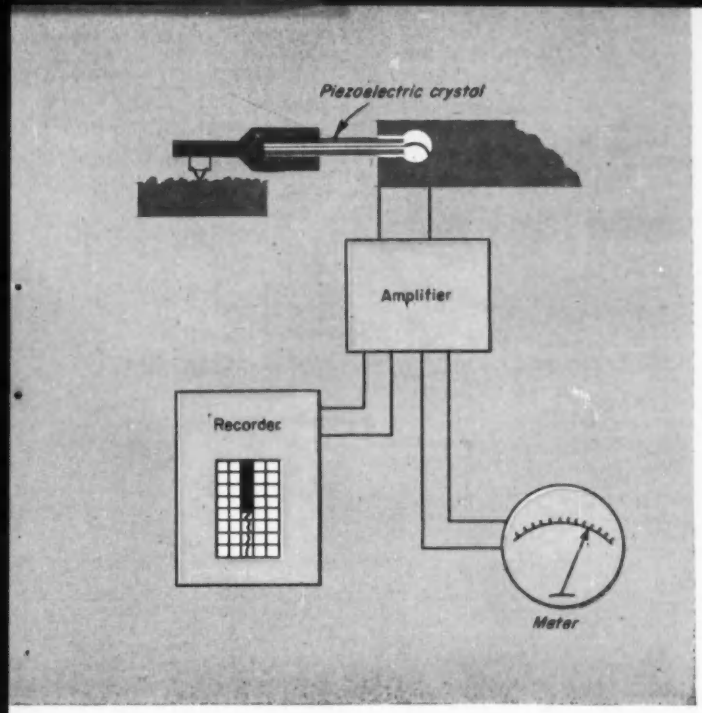
The required attenuation is less than might be expected; investigation showed that when long and short waves are measured in combination, the long wave will have little effect if its amplitude is less than about half that of the roughness. The investigation suggested the rate shown in Fig. 7 to be sufficient for most purposes. This rate would be produced by two successive resistance-capacity couplings of equal time constant, such as would occur naturally in the design of an amplifier, and is therefore highly economical. It seemed in line with the rate adopted quite independently for then current American instruments, and is now standardized as the acceptable minimum.

WAVINESS

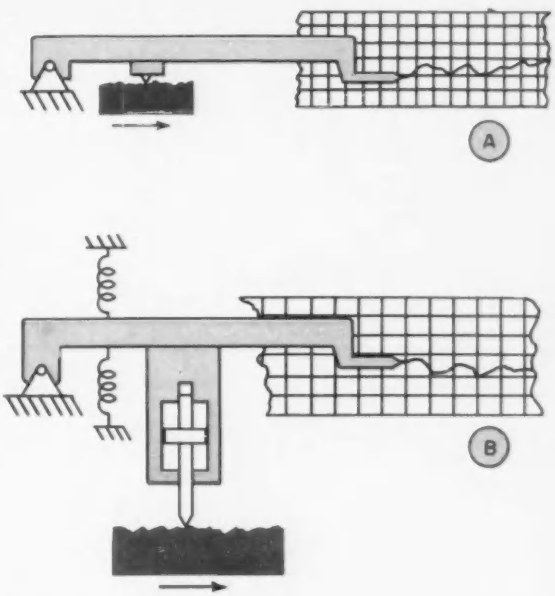
Waviness has generally been measured as the total height of profile from peak to valley, including the roughness, but provision is also made in B46.1-1955 for measuring waviness as a departure from the mean line. It can be measured together with roughness simply by increasing the roughness-width cutoff to include waviness (provided of course that the instrument allows a sufficient length of traverse relative to a datum of adequate quality).

Waviness can often be separated from roughness by a wave-filter attenuating short instead of long wavelengths, as shown by curve *B* in Fig. 7. Requirements differ from those for the roughness filter in that the wave-filter must transmit the harmonics of waviness as much as possible without running into the roughness itself, and can usually have a sharper cutoff; phase distortion, however, will be less important because it will only affect higher harmonics.

A problem arises with instruments providing both roughness and waviness measurements by the turn of a switch. The question, where to begin the waviness pass-band in relation to each roughness pass-band, must be carefully considered. If the one is arranged to begin where the other ends, as shown by curves A and C taken as a pair, the transmission characteristics will overlap; and, however sharp the attenuation, a surface having nothing more than a regular tool mark



5 A piezoelectric crystal . . .
generates voltage as a function of the bending force.



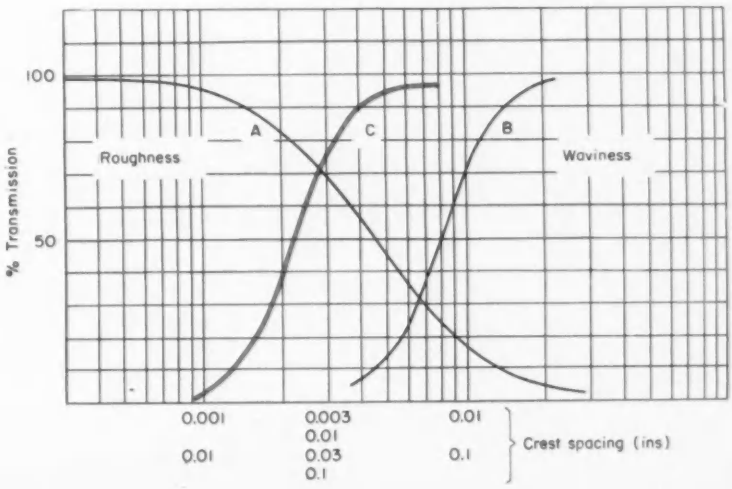
6 Mechanical equivalent . . .
of an inductive bridge is a straight lever multiplication (A) of as much as 100,000:1. Equivalent of the moving-coil pickup is a spring-centered lever driven by an oil dashpot with stylus mounted on the floating piston (B).

with a crest spacing near the cutoff would be wrongly read to have about as much waviness as roughness. It would seem better, especially in purely numerical instruments, to leave a gap between the end of each roughness band and beginning of the corresponding waviness band. The waviness might well start at what would be the next standard cutoff (curves *A* and *B*), and for successive pairs in the following table:

Roughness width cutoff	Waviness cutoff
0.003 in.	0.01 in.
0.01 in.	0.03 in.
0.03 in.	0.1 in.
0.1 in.	0.3 in.
0.3 in.	1.0 in.

Choice and separation of the transmission characteristics must reflect not only theoretical considerations, but also cost of roughness control in engineering production. While big advances have been made in simplifying instruments, the ideal–giving every machine operator concerned with finish an instrument for checking it, as freely as he is given gages necessary for dimensional control–is still perhaps a distant vision. Fortunately, present standards seem well in line with further progress toward this goal.

EDITOR'S NOTE: The Formed Steel Tube Institute has a recommended procedure for measurement of tube finish which was published under the title, "More on Surface Finish Inside Tubes," Apr. '57, p 166.

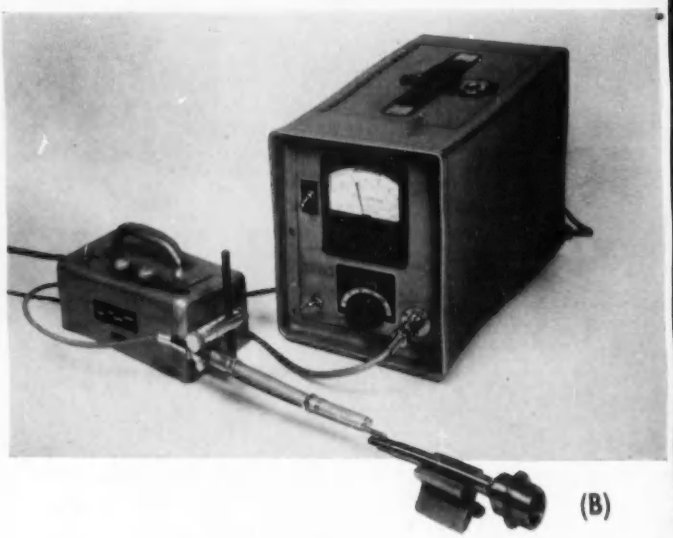


7 Pickup . . .
must be sensitive to high frequencies (A) but block low frequencies (inverse of crest spacing) to measure roughness but not waviness. Conversely, waviness (B) requires pickup to block high frequencies, and respond to low frequencies.

SURFACE FINISH

- tolerance and cost
- techniques of measurement

(A)



(B)

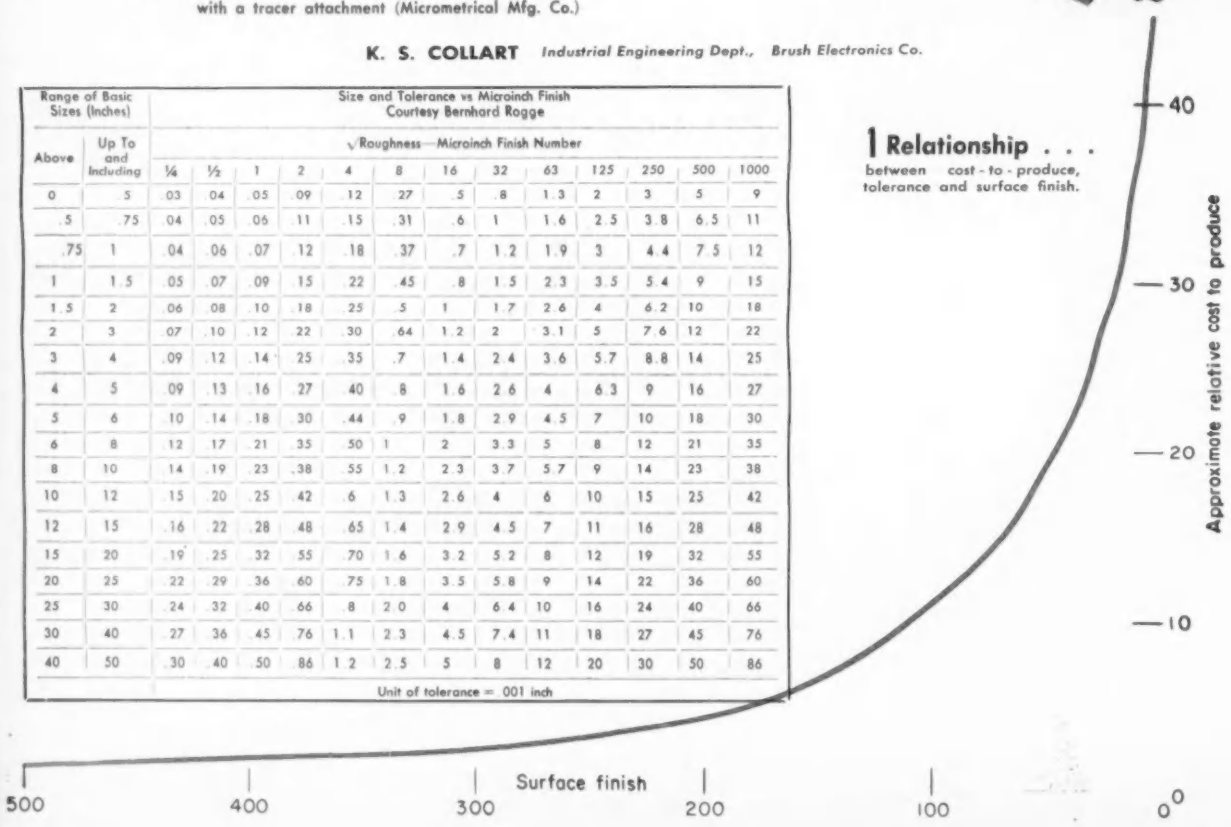
Small, convenient . . . portable instruments are available for measuring surface finish. Stylus is mounted in a tracing head stored in the case cover during transport of the Surfindicator (A) (Brush Electronics Co.). The Profilometer (B) is shown with a tracer attachment (Micrometrical Mfg. Co.)

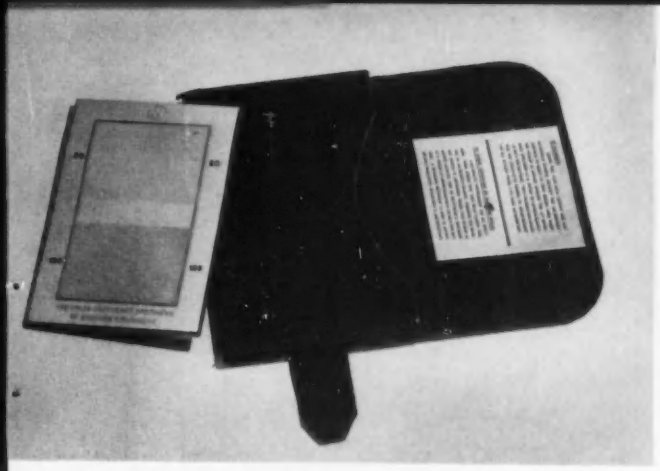
K. S. COLLART *Industrial Engineering Dept., Brush Electronics Co.*

Range of Basic Sizes (Inches)		Size and Tolerance vs Microinch Finish Courtesy Bernhard Rogge												
		√ Roughness—Microinch Finish Number												
Above	Up To and Including	¼	½	1	2	4	8	16	32	63	125	250	500	1000
0	.5	.03	.04	.05	.09	.12	.27	.5	.8	1.3	2	3	5	9
.5	.75	.04	.05	.06	.11	.15	.31	.6	1	1.6	2.5	3.8	6.5	11
.75	1	.04	.06	.07	.12	.18	.37	.7	1.2	1.9	3	4.4	7.5	12
1	1.5	.05	.07	.09	.15	.22	.45	.8	1.5	2.3	3.5	5.4	9	15
1.5	2	.06	.08	.10	.18	.25	.5	1	1.7	2.6	4	6.2	10	18
2	3	.07	.10	.12	.22	.30	.64	1.2	2	3.1	5	7.6	12	22
3	4	.09	.12	.14	.25	.35	.7	1.4	2.4	3.6	5.7	8.8	14	25
4	5	.09	.13	.16	.27	.40	.8	1.6	2.6	4	6.3	9	16	27
5	6	.10	.14	.18	.30	.44	.9	1.8	2.9	4.5	7	10	18	30
6	8	.12	.17	.21	.35	.50	1	2	3.3	5	8	12	21	35
8	10	.14	.19	.23	.38	.55	1.2	2.3	3.7	5.7	9	14	23	38
10	12	.15	.20	.25	.42	.6	1.3	2.6	4	6	10	15	25	42
12	15	.16	.22	.28	.48	.65	1.4	2.9	4.5	7	11	16	28	48
15	20	.19	.25	.32	.55	.70	1.6	3.2	5.2	8	12	19	32	55
20	25	.22	.29	.36	.60	.75	1.8	3.5	5.8	9	14	22	36	60
25	30	.24	.32	.40	.66	.8	2.0	4	6.4	10	16	24	40	66
30	40	.27	.36	.45	.76	1.1	2.3	4.5	7.4	11	18	27	45	76
40	50	.30	.40	.50	.86	1.2	2.5	5	8	12	20	30	50	86

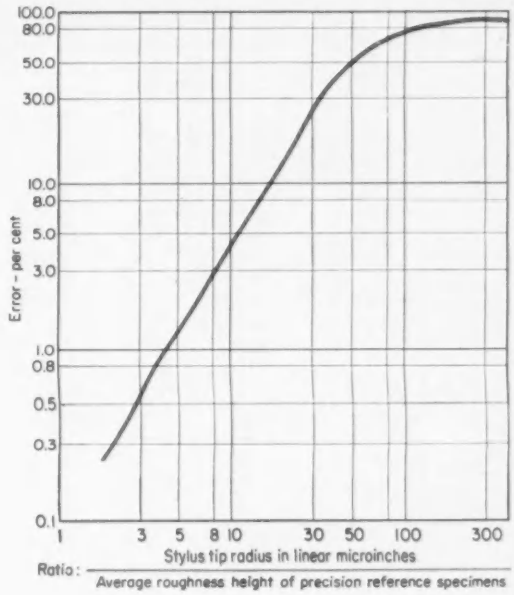
Unit of tolerance = .001 inch

1 Relationship . . . between cost-to-produce, tolerance and surface finish.





2 Stylus calibration curve . . . (right) used with the reference specimen shown above. Note two areas on reference specimen of 20 and 125 microinches.



Tolerances in the range of 0.0001 in. are significant only if initial wear of the peaks of surface irregularities will not radically alter the original dimension. This alteration is possible, on soft materials, by the insertion of a plug gage. There is a complex relationship between basic size of part, tolerance and surface finish. An approximation of this relationship is given in Fig. 1.

Generating fine surfaces often requires secondary or specialized operations that increase cost of these surfaces rapidly (Fig. 1). However, extremely fine finishes (with concomitant high costs) are not always desirable. An engine-cylinder bore cannot support its lubricant if too smoothly finished, just as too rough a surface will rupture the lubricant and cause rapid wear of piston rings.

Function, economics and tolerance all play important roles in selecting optimum finish for a given part. This finish may be defined as the roughest that will yet meet the requirements of product performance and appearance.

STRESS CONCENTRATION AND CORROSION

Surface irregularities may be critically important in highly stressed parts. Fatigue cracks usually start in the microscopic valleys on a surface and, once started, progress rapidly through the part. Parts rotating at very high speed may seem adequately sturdy for the calculated centrifugal loads but they may fail after relatively short running lives because of fatigue cracks originating at too rough a surface.

There is also close relationship between surface finish and corrosion resistance, particularly when high stresses are involved. Stress concentrations may lift the stress in a surface irregularity above the yield point. A small crack opens, baring new metal to the surrounding corrosive medium. This combined action accelerates rapidly until the part cracks or becomes so pitted that function is impaired.

TOOL FINISH

Tool life is a function of surface finish. The working surface of a cutting tool is formed by the intersection of two or more planes. The edge can only be as smooth and durable as these planes. Hand stoning refines the surface finish of the planes, permitting more even distribution of cutting load, and tool performance and life are improved.

MEASURING TECHNIQUES

It is evident that a certain amount of care is required for accurate, repeatable roughness readings. Dragging the pickup across the work carelessly will result in erratic indications. Instrument manufacturers offer attachments for smooth automatic tracing at the proper speed, but perfectly acceptable measurements can be made by hand. Traces should be made smoothly without stopping or jerking.

Reasonable care must be taken to eliminate setup errors. For example, measurements on curved surfaces should be made in a manner that will eliminate effects of the radius of curvature. Rocking a pickup at any time during a trace will cause spurious readings.

Equipment is available for checking most surfaces. However, tracing heads cannot reach the very small surfaces. An awareness of practical equipment limitations will permit best use of these instruments.

INSTRUMENT CHECKING

Calibrated samples are available from certain manufacturers which may be used to evaluate instrument performance as well as check stylus-tip condition.

There is a direct relationship between stylus-tip radius, surface finish and the error in a surface-roughness meter reading: the larger the tip radius and the finer the surface being measured, the larger the meter-reading error. This relationship has been graphed (Fig. 2); by setting the instrument to read correctly on a fairly rough surface, the error read when tracing a known fine finish will permit determination of stylus-tip radius.

This graph may be used in reverse to check the accuracy of instrument readings. With a known radius stylus and calibrated surface blocks, make several readings on blocks of varying roughness. Apply the correction called for by the graph and compare to the known roughness of the calibrated blocks.

CAM AND GEARS

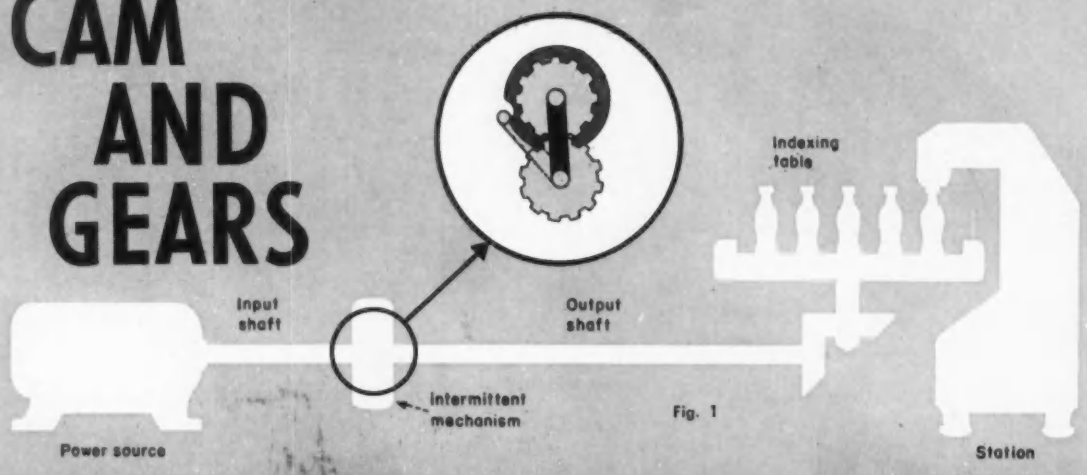


Fig. 1

. . . join to stop shock loads

Here's how a new intermittent mechanism avoids trouble peaks that occur in operation of high-speed or large-mass machinery.

JOSEPH STILES BEGGS, *Professor of Engineering*
University of California

RAYMOND STILES BEGGS
Hughes Aircraft Co., Culver City, Calif.

Trouble with shock loads can be avoided with a cam-and-planetary-gear system when you want to use intermittent motion in high-speed machinery. Equally useful for driving large-mass equipment, this new method converts constant motion into a start-and-stop type with low acceleration and deceleration peaks. It also allows varying the dwell period per cycle merely by changing a cam.

The device is installed, of course, between the input shaft from the power source, and whatever intermittently-rotating mechanism is being used, such as an indexing table, Fig. 1. Its method of rounding off peaks consists of a sequence of actions:

Counterclockwise revolution of the planetary carrier, Fig. 2, causes the planet gear to roll around the stationary sun gear. A point P on the planet gear, or on the cam attached to the gear, will trace an epicyclic curve, as shown by the dotted line. The follower, keyed to the output sleeve concentric with the input shaft, is driven counterclockwise by the cam surface until the roller drops into the cam slot. Then the follower begins to decelerate. Somewhat prior to the cusp of the epicyclic curve, point Q, the follower will begin to dwell—length of dwell and type of acceleration and deceleration curves depending upon the contour of the cam slot.

After the dwell, the follower is again driven in front of the cam. In Fig. 2, the follower is stationary for 10° of each 360° revolution of the input shaft. If the input shaft slows down, it is possible for the follower to over-ride and break contact with the cam surface. To avoid this, a grooved cam can be used in place of the plate can, or the follower can be spring loaded to follow the contour of the cam; the analysis, however, will be similar.

SAMPLE PROBLEM

To obtain a 10-sec dwell every 360 sec with uniform acceleration the following program is set up: Velocity of the driver, $\theta' = 1°/\text{sec}$. At time $t = 0$, the velocity of the follower is $\phi' = 1°$ sec. From $t = 0$ until $t = 10$, acceleration of the follower is $\phi'' = -0.1°/\text{sec}^2$ (single prime mark denotes velocity; double prime mark, acceleration). From $t = 10$ until $t = 20$, $\phi' = 0$ and $\phi'' = 0$. From $t = 20$ until $t = 30$, the follower catches up with the driver with uniform acceleration and deceleration, Fig. 3, so that $\phi' = 1°/\text{sec}$ when $t = 30$.

The motions are found from this information. From $t = 0$ until $t = 10$, $\phi'' = -0.1°/\text{sec}^2$. Integrating with respect to time gives $\phi' = -0.1\,t + 1$, because $\phi' = 1°/\text{sec}$ when $t = 0$. Integrating again gives $\phi = -0.05\,t^2 + t$, because $\phi = 0$ when $t = 0$. From $t = 10$ until $t = 20$, $\phi = 5°$. At $t = 30$, displacement $\theta = 30°$. Therefore, to catch up, ϕ must increase from 5° to 30° per sec in 10 sec. A graph of ϕ' versus t is shown in Fig. 4. The initial and final velocities are known. The graph contains straight lines of equal and opposite slope with the area under the velocity curve being the distance turned by the follower, 25°. If T = the time to accelerate and a = the absolute value of the acceleration and deceleration, then the equation for the area under the velocity graph is

$$25 = 1/2[(aT)T + (aT-1)(10-T)] + 1(10-T) \qquad (1)$$

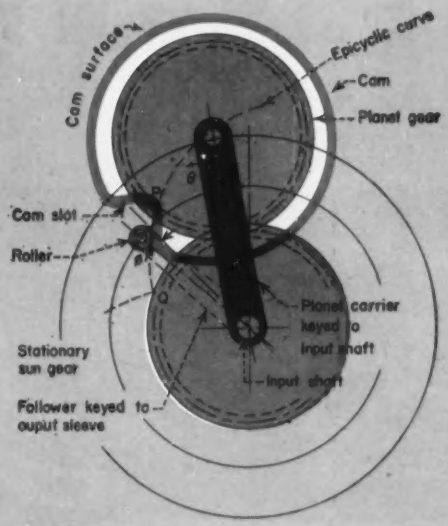


Fig. 2

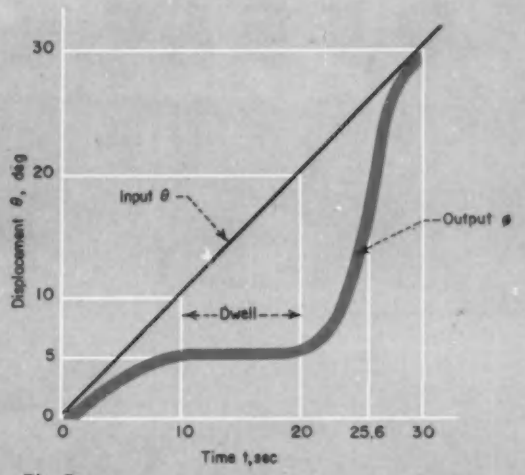


Fig. 3

The equation for straight line segments with equal magnitudes of slope is

$$aT/T = (aT-1)/(10-T) \qquad (2)$$

Solving Eqs (1) and (2) simultaneously gives $a = 0.812$ deg/sec^2 and $T = 5.61$ sec. Integrating the acceleration equations from $t = 20$ to $t = 25.61$ gives

$$\phi = 0.406\ (t - 20)^2 + 5$$

and integrating from $t = 25.6$ to $t = 30$ gives

$$\phi = -\ 0.406\ (t - 25.6)^2 + 4.56\ (t - 25.6) + 17.75$$

To obtain coordinates of the center of the cutter which machines the cam (assuming it has the same diameter as the cam follower), coordinates of the follower in the XY coordinate system, Fig. 5, are transferred to the X_1Y_1 system for the cam. Writing S and C for sine and cosine, the equations of transformation are (Rererence: Beggs, J. S., *Mechanism*, McGraw-Hill, 1955, page 70)

$$x_1 = (y - 2r\ S\ \theta)S\ 2\theta + (x - 2r\ C\ \theta)C\ 2\theta \qquad (3)$$

$$y_1 = (y - 2r\ S\ \theta)C\ 2\theta - (x - 2r\ C\ \theta)S\ 2\theta \qquad (4)$$

As an illustration the dwell is started when the position of the driver, $\theta = 0$. Designating the corresponding position of the follower as β, let $\beta = 45°$. Symbol r is the pitch circle radius of the gears, and kr the distance between centers of the roller and sun gear. In Fig. 5, k has been given three different values for comparison. If k equals $\sqrt{2}$ then $x = r$ and $y = r$ while the follower is stationary. Substituting these values in Eqs (3) and (4) gives

$$x_1 = a(1 - 2\ S\ \theta)S\ 2\theta + (1 - 2\ C\ \theta)C\ 2\theta$$

$$y_1 = a(1 - 2\ S\ \theta)C\ 2\theta - (1 - 2\ C\ \theta)S\ 2\theta$$

These equations are plotted in Fig. 5. The pressure angle depends on the size of the roller, k, β, and the dwell. If the dwell is too long, the pressure angle will become too great.

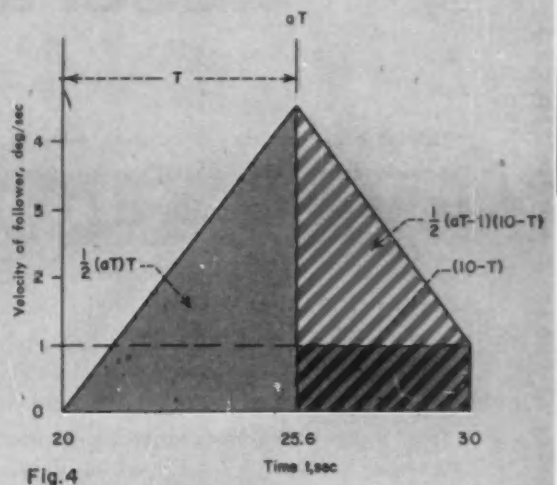


Fig. 4

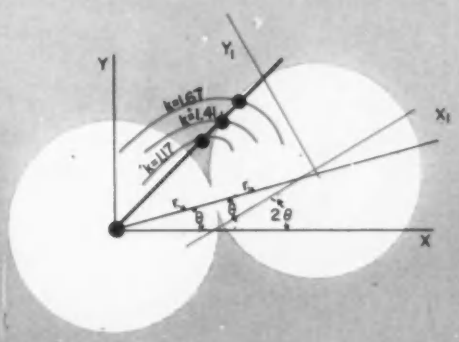


Fig. 5

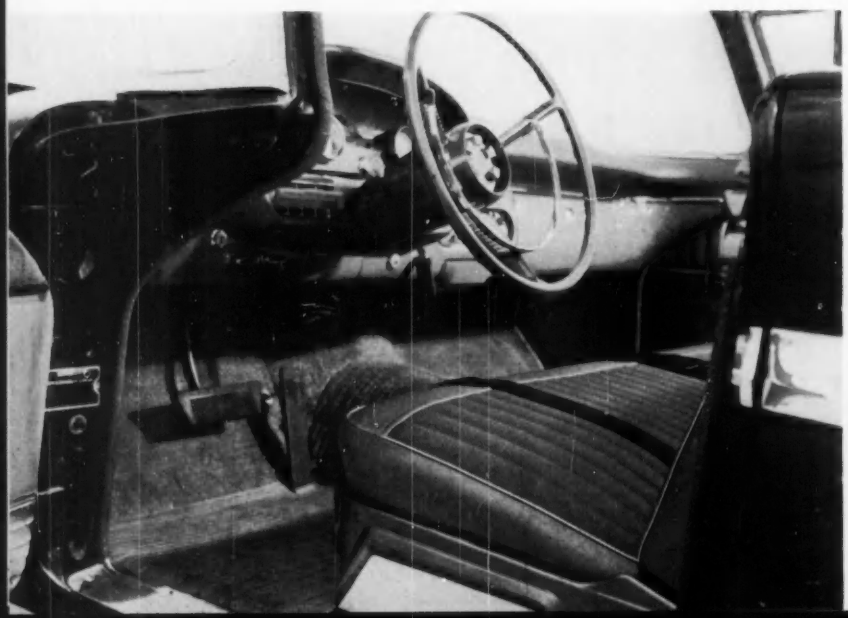
DESIGN FEATURES

Edsel's hat goes in the ring

Coming out of a tight turn on the proving grounds, this four-door hardtop is one of the Ranger series which leads off Ford's Edsel lineup. Other Ranger models available are a two-door hardtop, and two-door and four-door sedans. Pacer, Corsair and Citation series round out a line of 13 Edsel passenger cars plus five station-wagon models. Rangers compete directly with Pontiac and Dodge, while the Citation series challenges the Oldsmobile 88, the Buick Super and the DeSoto.

Edsel styling retains low straight lines characteristic of all Fords, but with distinctive modifications. The front bumper, in two sections, is on both sides of a vertical center grille reinforced by an impact ring. The grille blends into hood contours to create the "vertical theme" characterizing all Edsels. Bumper guards have protruding rubber pads to prevent minor defacement when parking. Dual headlights in the front fenders, and parking lights recessed in the horizontal grilles give driver-control over a wide range of illumination. Outboard lights are used alone for low beam; all four lights give high beam. Turn signals are in the parking lights and can be seen from the side.

Rear-end styling is characterized by horizontal decks, instead of fins, terminating in two-section, horizontal



Pushbuttons in steering-wheel hub . . .

choose transmission speeds by energizing a relay to control motor which engages selected transmission mechanism. Buttons for Park, Reverse, Neutral, Drive, and Lo are indirectly lighted for night driving. When starting engine, selector must be in Park or Neutral position. Added safety feature: Transmission can be shifted to Park position with key off, but not out of Park unless key is on. Built-in interlock prevents shifting into Reverse or Park above a low, safe speed.

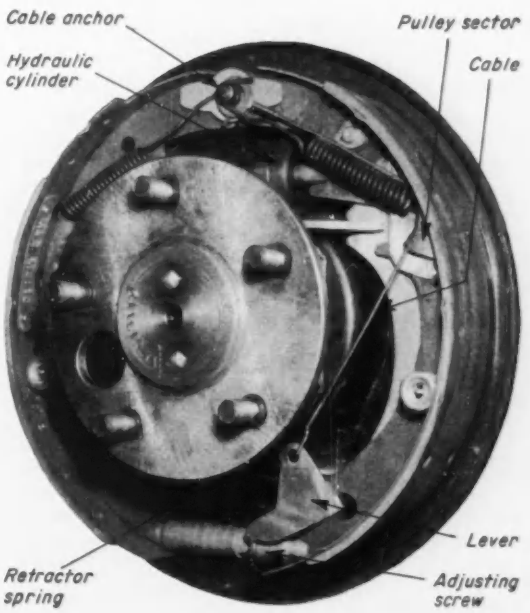
tail lights. Outboard sections function both as stop lights and turn indicators. The one-piece rear bumper has rubber-padded guards. All models have wide-rim wheels taking 14-in. tubeless tires.

Edsel body and chassis construction show unmistakable resemblance to others in the family of Ford cars. Frames have welded box-section side rails, contoured outward between the axles to accommodate a depressed floor pan; five crossmembers form a ladder-like design. Ranger- and Pacer-series frames have a 118-in. wheelbase; station-wagon wheelbase is 116 in. Wheelbase of Corsair and Citation series is 124 in.

On all frames, the two forward crossmembers support lower control arms of the swept-back ball-joint suspension. It has coil springs. Rear axles are suspended on conventional leaf springs. Second and third crossmembers support the engine mounts on all but 124-in. wheelbase frames; on these frames, front engine mounts are on the side rails.

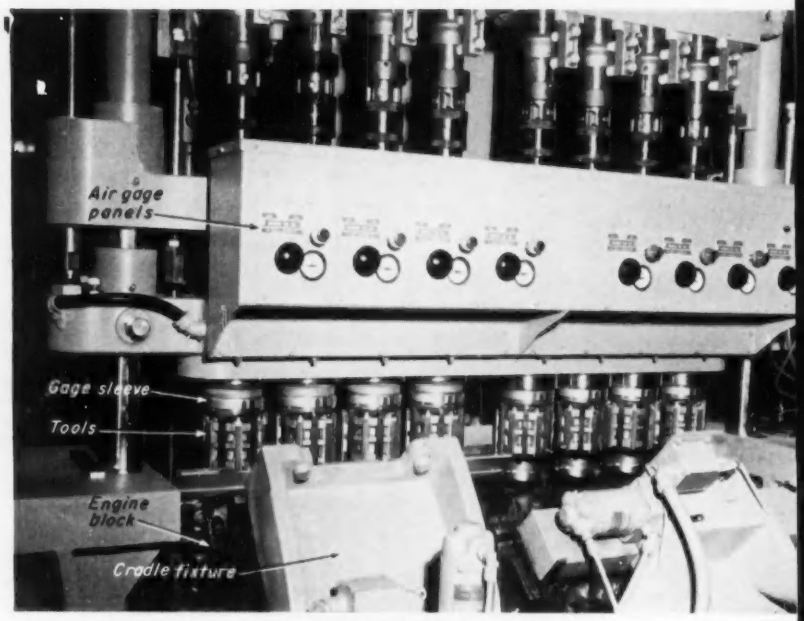
Two V-8 engines are available for Edsels. At 4,600 rpm, the 361-cu. in. displacement engine is rated at 303 bhp, the 410-cu in. displacement engine at 345 bhp. Both have a 10.5:1 compression ratio. In the 361-cu in. engine, bore is 4.05 in. and stroke is 3.50 in.; 410-cu in. engines have a 4.20-in. bore and 3.70-in. stroke. Overhead valves operated with hydraulic tappets are used in both. Ranger, Pacer and station-wagon series have the 303-hp engine; Corsairs and Citations use 345 hp.

Compact panel groups driver's instruments and controls . . .
in front of the steering wheel, with speedometer in top center position. Immediately below at each side are a tachometer, fuel gage, clock, and control for heating and air conditioning. Next, tier has switches for lights and antenna at left; for heater blower, windshield wiper and cigarette lighter at right. At bottom, two groups of warning lights draw driver's attention to oil pressure, generator, brake, fuel level, open doors, oil level, and hot or cold engine temperatures.



Brake shoes are adjusted for wear automatically . . .
Each time the brake mechanism is actuated with the car moving backward, a cable retracts a pawl at lower end of the secondary shoe. Cable is anchored on a pin above the hydraulic cylinder. When hydraulic pressure is released, brake shoes return to centered position and lower tension spring pulls pawl downward to rotate brake-adjusting screw. Motion of secondary shoe controls this action to prevent over-adjustment.

Cylinder Size Controlled AUTOMATICALLY

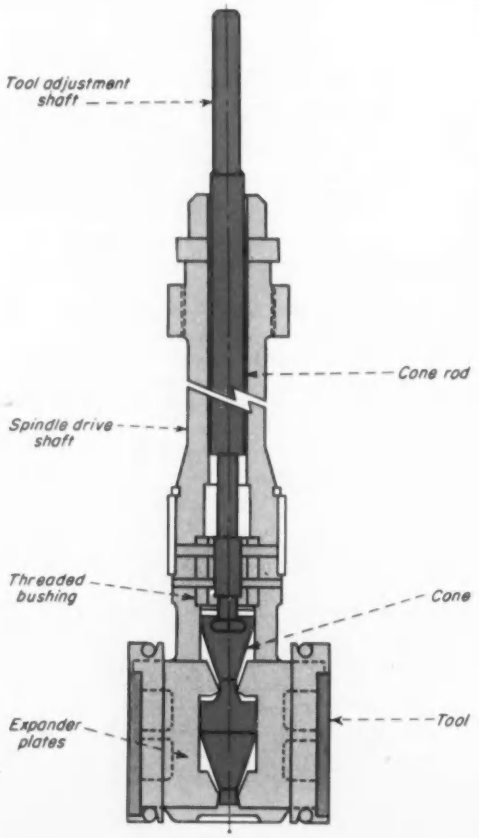


Automotive engine cylinders are now finish-sized individually to fit any selected piston size. The time-saving procedure is made possible by an eight-spindle microhoning machine developed by Micromatic Hone Corp., Detroit, Mich. Holding two blocks at a time, a cradle tilts them to position each cylinder bank for the cutting operation. Each honing tool carries an air-gage sleeve and can be expanded electrically from the control console.

Bore size is measured by air jets . . .

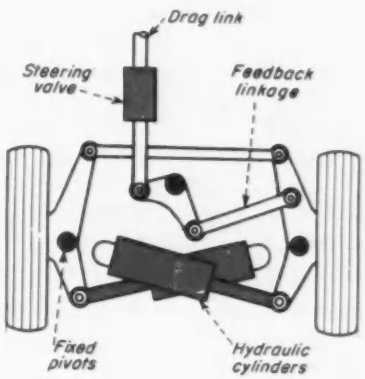
in the gage sleeve which strokes with and around the tool-drive shaft, but floats independent of tool position. Gage sleeve is slightly smaller than diameter of finished bore. As desired diameter is approached, gage enters bore with tool and indicates diameter on a dial. When a preset clearance is reached between jets and bore, decreased back pressure actuates a pressure switch to stop cutting cycle. Pneumatic controls include a regulator unit mounted on the machine close to the tool; size indicators and remote setting controls on a console. Diametric measurements are accurate to 0.0003 in. Bore size is adjustable through a range of 0.004 in. while the machine is in operation. Gage system components are made by Pratt and Whitney Corp.

Expansion and collapse of honing-tool mechanism are controlled electrically. Two rates of feed speed are used during expansion phase; a single speed collapses the tool. Tool-adjustment mechanism is operated by a d-c motor controlled by an adjustable speed drive from the console. Motor frame rotates with tool-drive spindle and receives armature current through a slip ring. Armature-shaft rotation, slowed by an 80:1 speed reducer, imparts linear motion to a threaded bushing. Bushing wedges cones in tool body against expander plates to force cutting stones against cylinder wall. To collapse tool, motor rotation is reversed.



Lift Truck Steers Hydraulically

Hydraulically steered rear wheels are featured on a 35,000-lb-capacity fork truck designed for heavy outdoor lifting and tiering work by the Industrial Truck Division of Clark Equipment Co., Battle Creek, Mich. The power steering made it feasible to place driver and controls over fender of left front wheel. This position gives the driver increased visibility when raising and placing loads.



Extended pitman arm shaft . . .

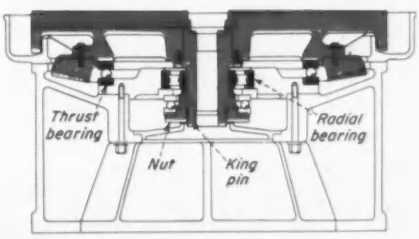
offsets the steering column from the centrally mounted pitman arm and drag links which carry steering action to rear of truck. Control valve is mounted in the final drag link and is spring centered. Dual hydraulic cylinders equalize turning effort in each direction, make possible a 70° turning angle and prevent mechanism from locking in either extreme position. Truck is called the CY-350.

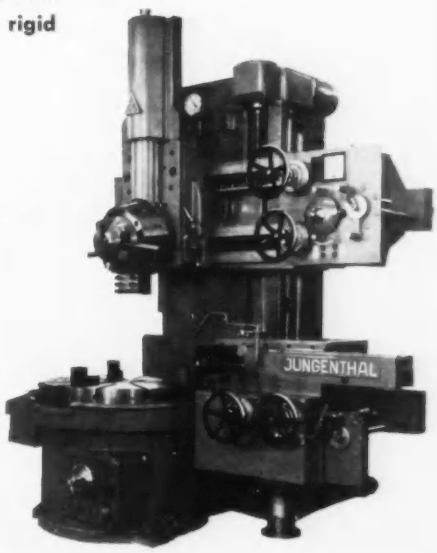
Preloaded Bearings Align Chuck

Thrust and radial bearings supporting the chuck of this vertical boring mill are preloaded by adjusting a nut on the lower end of the kingpin. Used in the DKE-1200 mill made by Jung Lokomotivfabrik, Kirchen an der Sieg, Germany, this compact bearing arrangement assures rigid alignment under all operating conditions.

Chuck and plate carrying the bearings . . .

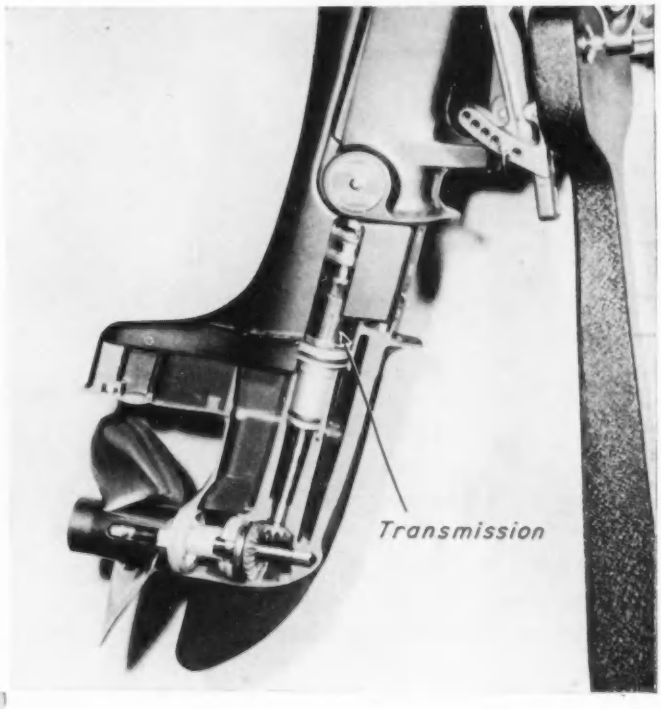
comprise a unit flange-mounted in the table with six bolts. Kingpin and inner race of the radial roller bearing are tapered so this bearing will be slightly preloaded when the nut is tightened to preload the large-diameter ball-thrust bearing. Preload on thrust bearing is normally between 8,800 and 11,000 lb. Top speed is 355 rpm. See p. 72 on how to reduce shock loads by preloading bearings.

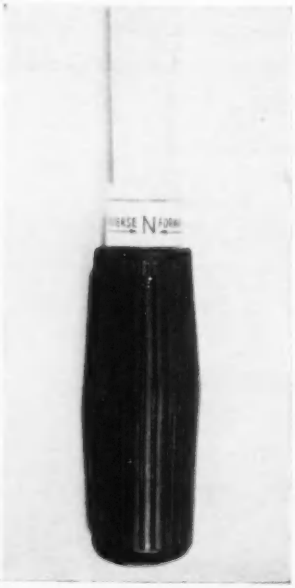




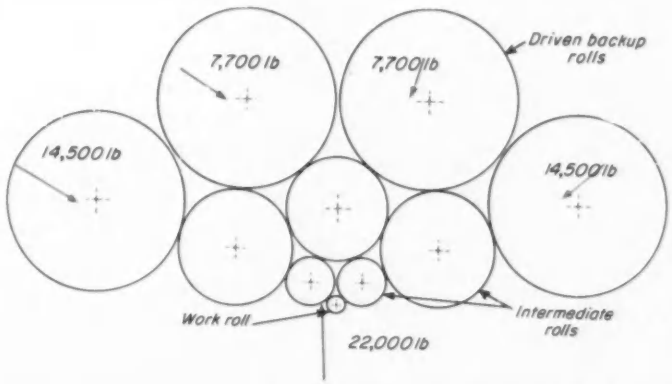
One-hand Control Reverses Outboard

Only a pair of spring clutches and a differential are needed to make up a transmission for the Mercury Mark 10, a 10-hp outboard motor built by the Kiekhaefer Corp., Fond du Lac, Wis. Transmission design allows the use of a twist-grip tiller handle that gives the boatman one-hand control of forward, reverse and neutral operation, as well as speed and direction.



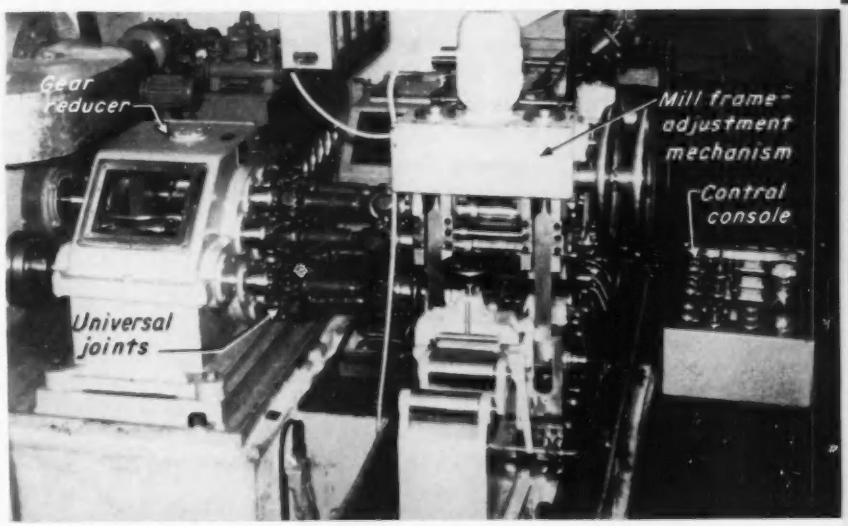


Weighing under 2 lb . . . transmission assembly is mounted in drive-shaft housing, just above water level. Assembly is made of four bevel gears, an idler carrier, two spring clutches. Smaller clutch connects input shaft to input bevel gear to select drive er neutral operation; larger clutch connects idler carrier to drum flange an input gear for forward, or to bore in driveshaft housing for reverse. In forward configuration, transmission rotates as a rigid assembly and gears do not transmit power. In reverse, a cam in the throttle linkage limits engine output to protect gears. Rotating twist-grip handle causes fingers to engage tangs and disengage springs. Twisting handle also operates cam linkage for throttle and ignition system. Engine is normally started with handle at neutral position. Exhaust gases are ejected through propeller hub.



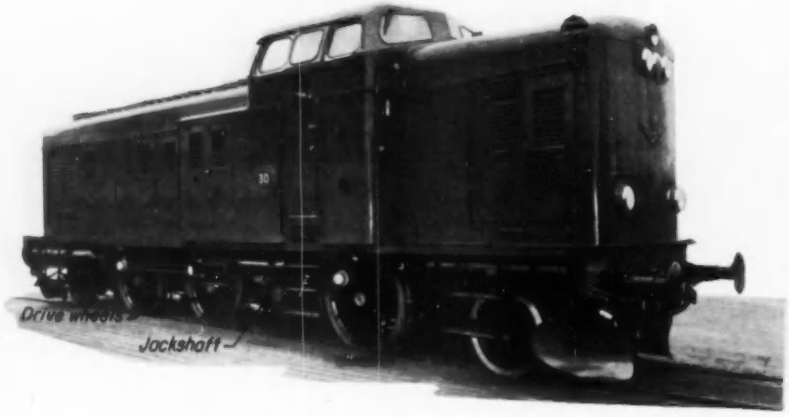
A reversing cluster mill designed by Loma Machine Manufacturing Co., Inc., of New York City rolls ultra-thin metal strip in narrow widths using small-diameter work rolls. Low ratio of contact length to strip thickness obtained with such rolls enables the mill to finish-roll strip to thinner gages with heavier reductions per pass and more passes between anneals. Also, a cluster arrangement of backup rolls supports slender work rolls to prevent bending in direction of forward tension. Outside backup rolls are driven by dual load-matched drives to obtain high torque input and equalize load between upper and lower rolls.

Twenty-high Mill Rolls Ultra-thin Strip



Design objective . . . was a low-cost rolling mill capable of making heavy reductions while holding close thickness tolerances. Applications include cold-rolling ferrous and non-ferrous metals to finishing gages from 0.0005 in. to 0.000125 in. Mill handles strip widths up to 4¼ in., uses work rolls as small as ⅜-in. dia to absorb separating forces up to 22,000 lb. Mill rolls in 20-high arrangement distribute effects of separating force as shown in upper diagram. Final backup rolls are one-piece forgings with a 1.3:1 length-to-diameter ratio. Roll journals are supported in babbitt-lined sleeve bearings and restrained axially by ball-thrust bearings. Intermediate backup rolls are supported by needle bearings and aligned axially with ball-thrust bearings. Work rolls ride between backup rolls and metal strip, and are restrained axially by thrust surfaces on a locking mechanism.

Based on Rohn alligator-frame design, mill has two forged-steel housing assemblies pivoted on trunions and with adjusting screws for setting mill bite. A lever-operated quick-acting cam mechanism is included to open mill for threading without disturbing roll setting. The beginning of a coil is threaded through the open mill and connected to the coiler drum before rolling starts. Rolls are raised by a motor drive or with handwheels. Handwheels adjust frames individually, or simultaneously when locked together with a clutch. All eight backup rolls are driven through universal joints from two d-c motors. One motor drives upper rolls, and the other drives lower rolls—an arrangement to reduce armature inertia and improve controllability of mill. Motor loads are matched electrically to equalize load distribution between upper and lower rolls. Variable-speed drive is arranged for constant-tension winding with controlled acceleration and deceleration. Bearings of backup rolls are lubricated by a closed circulating system. A separate closed system lubricates strip being processed.

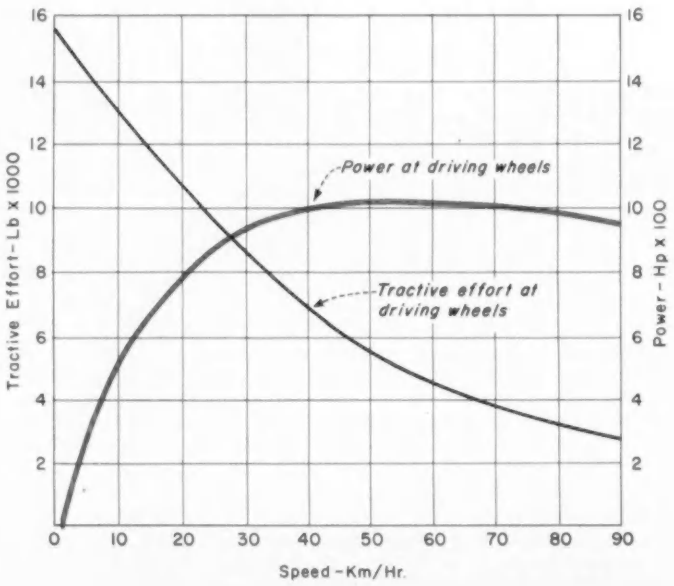


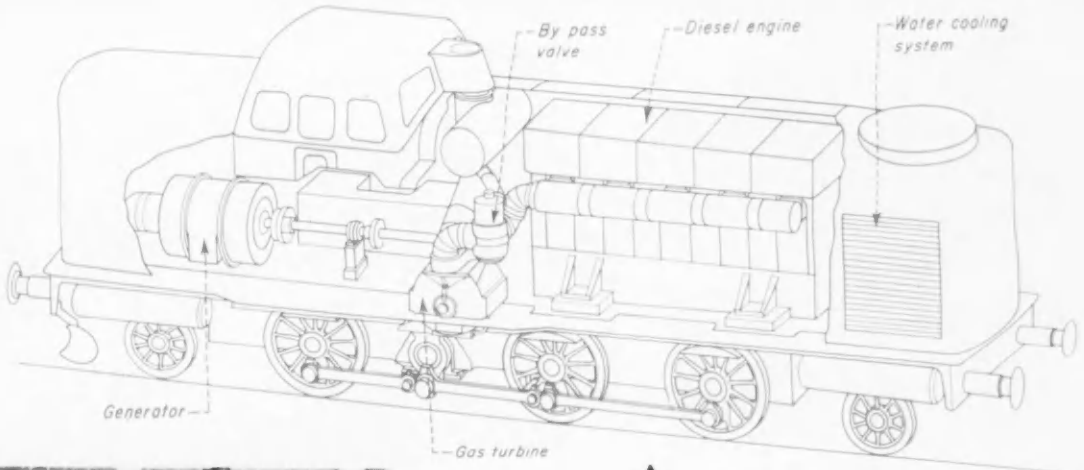
Turbine delivers 1000 bhp . . . to 4 ft-3 in. dia driving wheels when operating between 40 and 70 km/hr. Service weight is 138,000 lb and adhesion weight is 83,000 lb. Maximum speed is 90 kmph. Diesel exhaust gases enter turbine at about 53 psig and 930 F. Turbine drives an intermediate jackshaft through a double-reduction spur gear that includes hydraulically operated clutches for reversing direction of motion. Jackshaft is coupled to the three sets of drivers with connecting rods. Compact arrangement of power plant makes engine compartment narrow and gives operator good visibility. Locomotive frame is a conventional riveted and welded structure suspended on leaf springs.

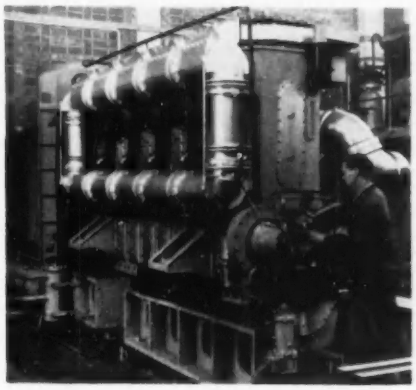
Diesel Exhaust Drives Locomotive Turbine

A gas turbine driven by exhaust gases and scavenging air from a vertical opposed-piston diesel engine powers a locomotive built by the Goetaverken Co., Gothenburg, for the Swedish State Railways. Compressor, used to supercharge the 5-cylinder engine, is built into the cylinders with its pistons connected to the upper engine pistons. Diesel output drives auxiliaries and compressor; tractive power is obtained from the gas turbine alone. Operating the turbine with low-temperature gases avoids requirements for special steel.

Tractive effort when starting . . . is about five times value obtained at top speed, and maximum over-all efficiency is about 31.5%. In a conventional diesel engine, about 20% of potentially available power is not used because gases are exhausted directly to atmosphere, but addition of turbine makes possible complete expansion of gases for maximum utilization of available energy. Although more power is required for supercharging, fuel consumption with this design is 0.44 lb per hp hr at the driving wheels when running at 2/3 maximum speed. This approximates economy of conventional diesel drives. Pneumatic balancing cylinders are provided to distribute load between driving axles and bogies at front and rear. This arrangement allows the operator to increase the load on the driving axles for starting.





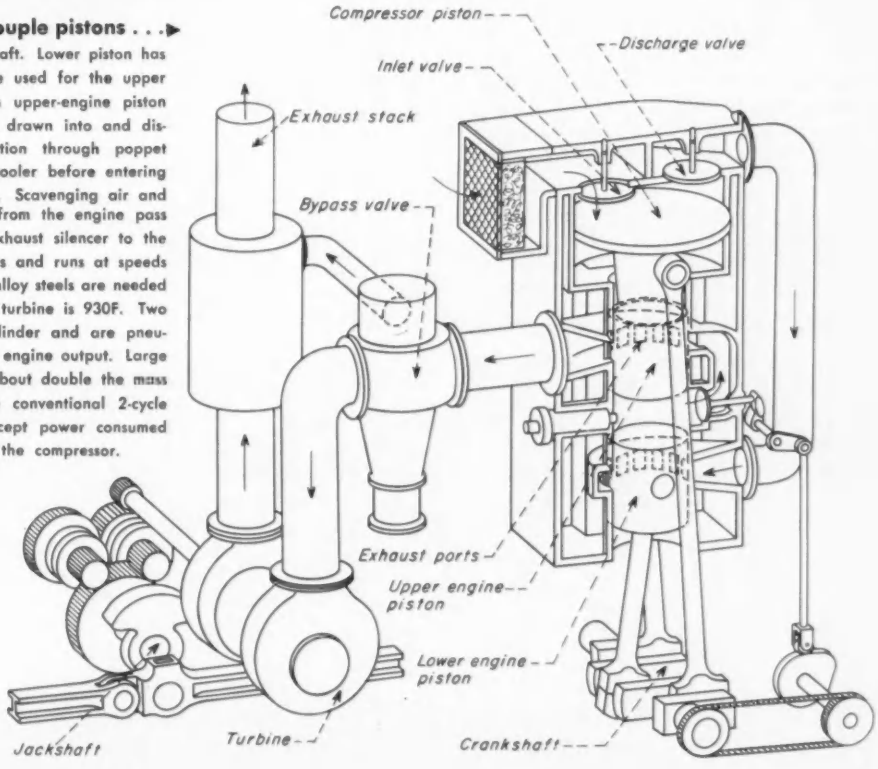


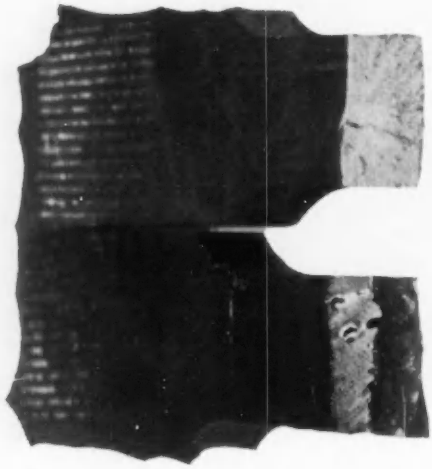
Engine is mounted over forward sets of drive wheels . . .

drives auxiliary equipment including generator, compressors, pumps and cooling fan. The 125-kva generator supplies power to heat the train. Compressor is belt-driven and supplies air for brakes, sander, whistle and pneumatic control system. Another compressor charges the air receiver that starts the engine. Pumps for lubricating and fuel oil are driven by the diesel engine. Air is drawn through louvers at each side of engine nose and discharged upward by cooling fan after passing over the heat exchanger tubes. Fan is driven through a hydraulic coupling controlled by a water-temperature thermostat. Gases are discharged from the turbine exhaust through stack in front of cab. When idling, a bypass valve directs gases away from turbine and discharges them directly into stack

Three connecting rods couple pistons . . .

in each cylinder to the crankshaft. Lower piston has single rod while dual rods are used for the upper stepped piston acting as both upper-engine piston and compressor piston. Air is drawn into and discharged from compressor section through poppet valves and passes through a cooler before entering the diesel combustion chamber. Scavenging air and hot exhaust gases discharged from the engine pass through the turbine and an exhaust silencer to the stack. Turbine has seven stages and runs at speeds up to 12,500 rpm. No special alloy steels are needed as highest gas temperature in turbine is 930F. Two injectors feed fuel to each cylinder and are pneumatically controlled to regulate engine output. Large compressor piston compresses about double the mass of air used in a comparable conventional 2-cycle engine. All engine output except power consumed by auxiliaries is absorbed by the compressor.





1 Globular weld deposition resulted in porosity shown below. Changing to a spray type of deposit produced sound weld above.

Magnesium castings can be welded without distortion

Salvage process is adapted to permit minor additions without preheating, porosity and cracking in the weld. Mechanical properties of weldments are also given.

H. MANSFIELD, *Project Engineer*
L. GESUALDO, *Senior Welding Technician, Wright Aeronautical Division, Wood Ridge, N. J.*

This new welding process eliminates preheating and considerably increases the rate of metal deposition. The result is sound welds with physical properties comparable to those of the casting alloy. Developed to salvage faulty magnesium castings, the process has given consistently satisfactory results for over two years. It allows adding metal to a magnesium casting to effect minor engineering changes or to adapt the same basic casting to different machine models, without risking the damaging distortion that is caused by preheating and slow metal-deposition rates characteristic of the standard shielded-arc, consumable-electrode process.

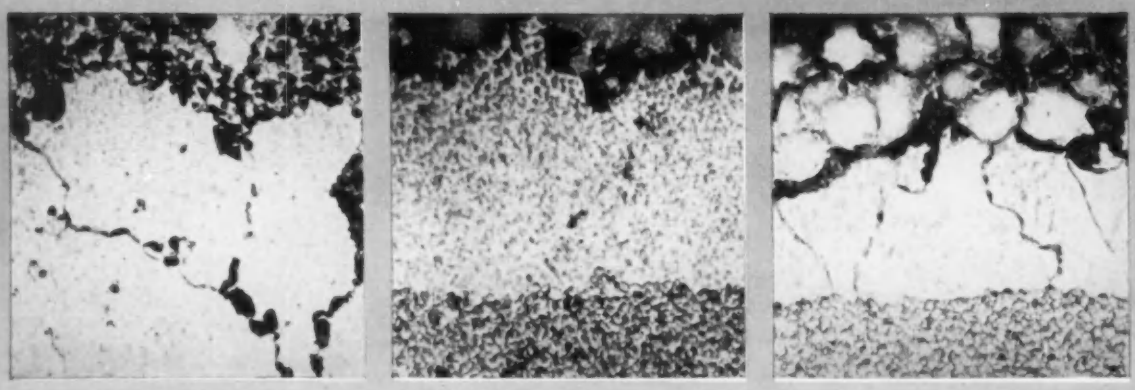
REQUIREMENTS OF THE PROCESS

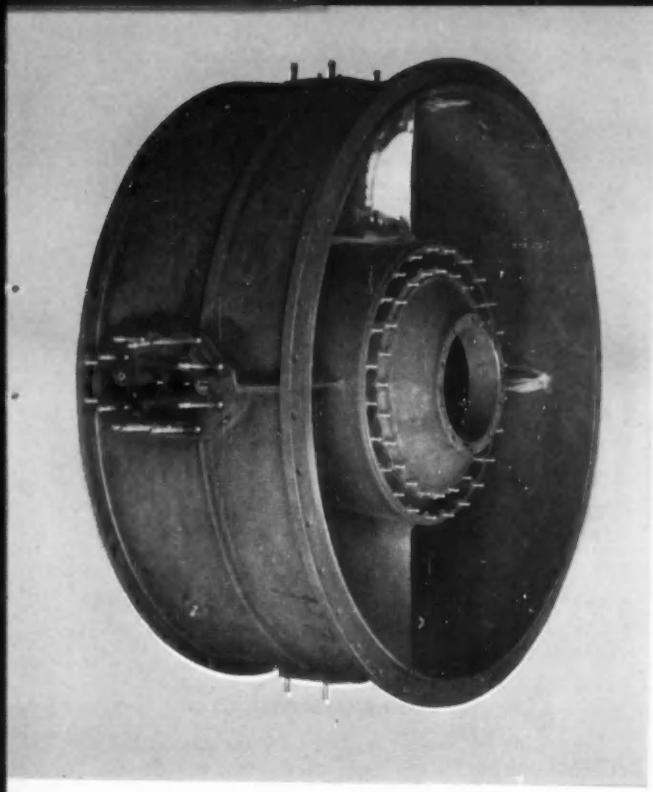
Tests on special blocks, then on actual production castings, showed best results obtained with a shielded-arc, consumable-electrode machine fed automatically by coiled-wire electrode. Equipment settings vary with section thickness. For a 1-in. section they are:

Amperes	170
Volts	28-32
Wire size	$\frac{3}{32}$ in.
Wire feed	165 in./min
Argon flow	100 cfh

Weld wire of a relatively high zinc content causes cracking. The cast metals were AMS-4424 and AMS-4434, so filler wire was required with composition reasonably close to that of those alloys, but lower zinc content. Comparable physical properties were also

2 Photomicrographs of welds show minor structural differences from the heat-treat cycle. Left, welding of an as-cast part, followed by normal solution treating and aging; center, normal solution treating and aging preceded and followed welding; right, a normally solution-treated and aged casting was welded and aged for 3 hr.





3 Low distortion with this process permits salvaging even machined castings like this main bearing support for the shaft driving the air compressor of a jet engine.

necessary, both as-cast and in the heat-treated condition. These requirements were met by J-1, an alloy generally used for forgings and extrusions (see Table).

WELD SOUNDNESS

Globular weld-metal deposition often caused porosity, but this was solved by a technique that deposited liquid filler metal as a continuous fine spray, Fig. 1.

Heat-treatment of castings prior to welding increased weldability by decreasing porosity and cracking, removing residual casting stresses, causing more homogeneous structure, reducing residual gases in the casting.

Heat-treating times and temperatures were those specified for the AMS-4424: solution heat-treating at 710 F for 17½ hr and aging at 350 F for 16½ hr. Aging at 350 F for 3 hr was also tried.

Prior impregnation of the casting produced unacceptable porosity through decomposition of the impregnant during welding.

Welds that proved sound on X-ray inspection consistently met the mechanical-properties requirements of the cast metals.

TESTS AND RESULTS

To determine best operating procedure, three methods were tried:

(1) Cast, weld, solution heat-treat, age.

(2) Cast, solution heat-treat, age, weld, solution heat-treat, age.

(3) Cast, solution heat-treat, age, weld, age for 3 hr.

Microstructures obtained, Fig. 2, indicate that differences in mechanical properties are not a result of structure.

Depth of weld has no apparent effect on mechanical properties. X-ray quality is reflected directly in the tensile strength. Either severe porosity, or porosity and small cracks, lower the ultimate tensile strength below the 25,000-psi minimum for the cast material. Yield strength, while lower where X-ray quality is poor, always meets the minimum of 12,000 psi. However, when a sound weld is tested, the minimum is bettered by at least one-third. Elongation and hardness are not significantly different. Weld soundness is needed to obtain satisfactory endurance strength.

DISTORTION

Welding causes negligible distortion of the castings, largest variation being 0.010 in. in 30 in. Maximum distortion caused by re-solution heat-treating and aging after welding is considerably greater (0.134 in. on a 34-in. casting). Limited aging (3 hr at 350 F) without re-solution heat-treatment causes much less distortion (0.010 in. max on a 30-in. casting) without sacrifice of mechanical properties.

Major limiting factor is the geometry of the casting, as the area to be welded must be readily accessible to the welding nozzle.

EDITOR'S NOTE: Magnesium-casting design was covered in "Quality and Cost of Magnesium Castings," March 1957 page 164. An article on "Casting Design" was published in October 1956 page 190.

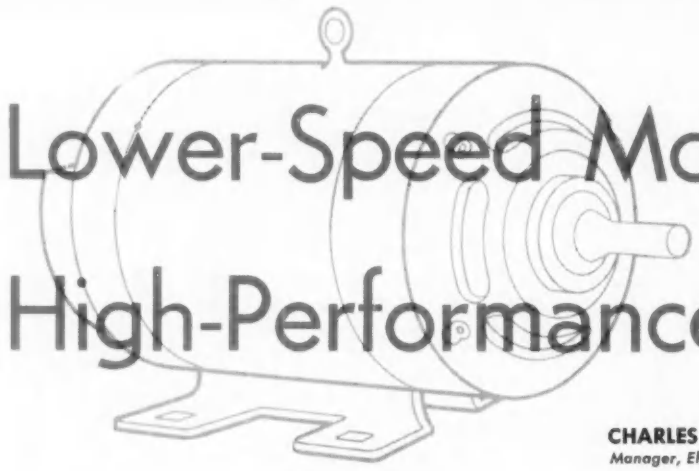
A number of processes lend themselves to casting magnesium: "Redesign for Die Casting," January 1956 page 156; "Shell Molding for Short-Run Production" March 1955 page 175; "Plaster Mold Casting," February 1955 page 193.

Articles on welding involving magnesium include: "Recommended Welding Processes," April 1893 page 229; "Spot-welding Aluminum and Magnesium Assemblies," March 1952 page 185.

Physical Properties of Metals Used in Tests

Condition	Alloy, %			Tensile, psi	Yield, psi	Elongation, %	Hardness, Brinell
	Al	Mn	ZN				
Dow "C" AMS-4434 Cast-Sol-Age	9.0	0.1	2.0	25,000	15,000	1.00	70–95
Dow "H" AMS-4424 Cast-Sol-Age	6.0	0.2	3.0	25,000	12,000	0.75	65–85
Dow J-1 Forged	6.5	0.2	1.0	38,000	22,000	6	57

Lower-Speed Motors for High-Performance Drives



CHARLES C. LIBBY
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Selection on the basis of speed instead of inertia may seem surprising but can avoid overheating problems—and with less investment. These facts are explained, and put to work for you in new reference tables giving inertias and kinetic energies of motors from 1 to 200 horsepower.

It is easy to overlook the speed of a motor when choosing one for high-performance drives. This oversight can lead to a motor of higher temperature rise, higher first cost, or of special design. Moreover, a motor with lower base speed can often take more starts or reversals per minute without overheating, even in drive systems with higher load inertias than motor rotor inertia.

When selecting a drive motor on the basis of maximum allowable temperature rise, the role of inertia as a producer of heat is usually overemphasized. Because the heat developed is directly proportional to the total connected inertia in terms of the motor-shaft speed, inertia is important; motor speed is often more important.

Heat produced in a motor accelerating from standstill to synchronous or maximum speed is given by the first equation in the box on page 98. Neglecting friction and any load torque, this heat equals the product of: (1) motor and machine inertia $(WR^2)_T$ in terms of motor-shaft speed, (2) square of motor speed N^2_M, and (3) a constant C depending on electrical design of the motor and other factors described in "Controlling Temperature Rise in Squirrel-Cage Induction-Motor Drives," January 1957 page 171.

For practical applications, let us examine some equations in terms of the kinetic energies involved. The total inertia $(WR^2)_T$ is the sum of two factors: motor-rotor inertia $(WR^2)_M$ and $(WR^2)_L$ which is load inertia of the machine parts referred to motor-shaft speed N_M. This is expressed in Eq (2), where N_L is load speed.

By substituting Eq (2) in Eq (1), Eqs (3) and (4) are derived. The last expresses total heat loss during an acceleration, as a sum of kinetic energies, therefore:

1. If full-load speed is kept constant, heat produced by kinetic energy of the load, and therefore the equivalent heat loss, remains unchanged.
2. But if motor speed is reduced, while motor inertia is held constant, the kinetic energy of the rotor—and therefore the equivalent heat loss—is reduced as the square of the speed reduction.

CHOOSING SPEEDS

Comparing two motors of same rated horsepower but different base speeds, the lower-speed motor will almost always have higher rotor inertia but frequently will have lower kinetic energy at full speed. In most cases the slower-speed motor is also a larger frame size. Therefore the temperature rise is further reduced by the increased frame area available for heat dissipation.

As a result, motors between 1 and 10 hp for duty cycles requiring frequent starting and reversing are often selected with base speeds below 1800 rpm. Also, for larger motors driving high-inertia systems which start infrequently, the base speed at which the required-horsepower motor has the lowest possible kinetic energy may be an important factor. An exception to this is the punch-press drive motor. This was discussed in "Driving High-Inertia Loads," April 1956 page 142.

To simplify the evaluation and choice of best motor speed for a given application, Tables I and II present synchronous speeds, rotor inertias, and rotor kinetic energies for NEMA Design B motors from 1 to 200 hp. Squirrel-cage rotors usually use copper or aluminum windings. Data in these tables pertain to rotors with copper windings; aluminum windings reduce rotor inertia 10 to 20%.

The kinetic energies given are based on synchronous speeds. To calculate for full-load speed, multiply by the square of the ratio of full-load speed to synchronous speed.

For example, a 3-hp motor has a kinetic energy of 220 ft-lb at 1800 rpm synchronous speed. Full-load speed is 1750 rpm. Therefore kinetic energy is reduced by a factor $(1750/1800)^2$ or 0.94, and the value of 220 ft-lb becomes 206.8, a reduction of about 6%.

REDUCTION IN HEAT

Effectiveness of substituting a lower-speed motor to reduce motor heat loss shows by comparing kinetic energy of the system before and after. For example, an 1800-rpm motor drives a 600-rpm load in a frequent-

Table I—Inertias and Kinetic Energies of Standard Squirrel-Cage Induction Motors, NEMA Design B, 1 to 40 Hp

Power supply is 2 or 3-phase, 60 cycles at 220 or 440 v. Kinetic energies are shown at synchronous speeds: motors are open, drip-proof for horizontal mounting.

Horsepower Ratings	Synchronous Speed, rpm	RERATED FRAMES			STANDARD FRAMES		
		Frame Size	Inertia, lb-ft²	Kinetic Energy, ft-lb	Frame Size	Inertia, lb-ft²	Kinetic Energy, ft-lb
1	1800	182	0.2	110	203	0.4	220
	1200	184	0.3	75	204	0.6	145
	900	213	0.4	55	225	0.7	95
1½	3600	182	0.1	220	203	0.5	1100
	1800	184	0.3	165	204	0.5	275
	1200	184	0.3	75	224	0.6	145
	900	213	0.4	55	254	1.2	165
2	3600	184	0.1	220	204	0.6	1320
	1800	184	0.3	165	224	0.6	330
	1200	213	0.4	100	225	0.7	170
	900	215	0.6	80	254	1.2	165
3	3600	184	0.1	220	224	0.7	1550
	1800	213	0.4	220	225	0.7	385
	1200	215	0.6	150	254	1.2	300
	900	254U	1.5	205	284	1.9	260
5	3600	213	0.3	660	225	0.8	1760
	1800	215	0.6	330	254	1.4	770
	1200	254U	1.7	415	284	1.9	470
	900	256U	2.1	290	324	5.9	815
7½	3600	215	0.4	880	254	0.8	1760
	1800	254U	1.3	715	284	2.1	1160
	1200	256U	2.1	515	324	5.9	1450
	900	284U	2.8	385	326	7.6	1050
10	3600	254U	0.8	1760	284	1.6	3530
	1800	256U	1.7	940	324	4.0	2210
	1200	284U	2.8	685	326	7.1	1740
	900	286U	3.3	455	364	8.3	1150
15	3600	256U	1.0	2200	324	1.9	4190
	1800	284U	2.6	1430	326	5.0	2750
	1200	324U	7.8	1910	364	7.6	1860
	900	326U	9.8	1350	365	10.1	1390
20	3600	284U	1.9	4190	326	2.4	5300
	1800	286U	3.6	1980	364	7.1	3920
	1200	326U	9.8	2400	365	9.5	2330
	900	.....	.....	.....	404	17.5	2410
25	3600	286U	2.3	5070	364	7.1	15680
	1800	324U	4.8	2650	364	7.6	4190
	1200	.....	.....	.....	404	16.0	3920
	900	.....	.....	.....	405	21.0	2900
30	3600	324	2.8	6170	364	8.3	18200
	1800	326U	6.1	3360	365	8.9	4900
	1200	.....	.....	.....	405	19.2	4720
	900	.....	.....	.....	444	27.2	3750
40	3600	326	3.6	7940	365	9.5	20900
	1800	.....	.....	.....	404	13.8	7600
	1200	.....	.....	.....	444	25.2	6170
	900	.....	.....	.....	445	33.6	4030

Table II—Inertias and Kinetic Energies of Standard Squirrel-Cage Induction Motors, NEMA Design, 50 to 200 Hp

Power supply is 2- or 3-phase, 60 cycles at voltages shown; kinetic energies are shown at synchronous speeds; motors are open, drip-proof for horizontal mounting.

Horsepower Ratings	Synchronous Speed, rpm	220/440 volts			2300 volts		
		Frame Size	Inertia, lb-ft²	Kinetic Energy, ft-lb	Frame Size	Inertia, lb-ft²	Kinetic Energy, ft-lb
50	3600	404	8.4	18,500	444	11.2	24,680
	1800	405	16.0	8,820	445	34.0	18,730
	1200	444	29.4	7,200	504U	74.0	18,180
	900	504U	58.0	7,990	505	96.0	13,250
60	3600	405	9.8	21,600	444	13.0	28,650
	1800	444	27.4	15,100	445	38.0	20,940
	1200	504U	58.0	14,200	504U	96.0	23,680
	900	505	75.0	10,330	584*	121.0	16,680
75	3600	444	12.8	28,080	445	17.0	37,470
	1800	445	33.6	18,510	504	50.0	27,540
	1200	505	79.0	19,350	584*	115.0	28,160
	900	505	88.0	12,120	584*	136.0	18,730
100	3600	445	17.0	37,470	504	29.0	63,920
	1800	504	44.0	24,240	505	58.0	31,950
	1200	505	92.0	22,530	584*	133.0	32,570
	900	585*	187.0	25,760	585*	187.0	25,760
125	3600	504	24.0	52,900	505	98.0	83,750
	1800	505	52.0	28,650	584*	138.0	76,010
	1200	585*	148.0	36,250	585*	148.0	36,250
	900	684*	371.0	55,100	684*	371.0	55,110
150	3600	505	29.0	63,920	584*	66.5	146,600
	1800	505	58.0	31,960	584*	88.5	48,760
	1200	585*	160.5	39,300	585*	160.5	39,300
	900	684*	410.0	56,480	684*	410.0	56,480
200	3600	584*	75.5	166,400	584*	75.5	166,400
	1800	585*	104.5	57,580	585*	104.5	57,580
	1200	684*	341.0	83,510	684*	341.0	83,510
	900	686*	490.0	67,500	686*	490.0	67,500

*Larger than NEMA frames, in accord with suggested standard for future design

Relationship of Inertia and Kinetic Energy to Heat Produced in a Motor

Definitions: H_T is total heat produced in motor during a single acceleration from standstill to synchronous or maximum motor-speed N_M; N_L is load speed. $(WR^2)_M$ and $(WR^2)_L$ are inertias of motor and load, respectively, while total inertia is $(WR^2)_T$. In Eqs (8) and (9), I is generalized term for inertia. The total kinetic energy of the system is E_T; E_M is kinetic energy of the motor, and E_L is kinetic energy of the load. C is a constant determined by motor design and has a fixed value for any individual motor.

Total heat loss in a motor is defined by the following equation

$$H_T = (WR^2)_T N^2_M C \qquad (1)$$

Total inertia is the sum of motor and load inertia referred to motor-shaft speed

$$(WR^2)_T = (WR^2)_M + (WR^2)_L \left(\frac{N_L}{N_M}\right)^2 \qquad (2)$$

Substituting Eq (2) in Eq (1), total heat loss of the system can be determined.

$$H_T = \left[(WR^2)_M + (WR^2)_L \left(\frac{N_L}{N_M}\right)^2\right] N^2_M C \qquad (3)$$

Multiplying through by $N^2_M C$,

$$H_T = [(WR^2)_M N^2_M]C + [(WR^2)_L N_L{}^2]C \qquad (4)$$

$$\text{or } H_T = E_M C + E_L C \qquad (5)$$

Therefore heat produced is the sum of that produced by motor kinetic energy plus load kinetic energy. By reducing motor speed, and consequently motor energy, we have a simple means of reducing heat generated.

Eq (6) and (7) pertain to an example discussed in text in which an 1800-rpm motor drives a 600-rpm load, and load inertia is four times motor inertia.

$$H_T = [I(1800)^2 + 4I(600)^2]C_1 \qquad (6)$$

$$\text{or} \quad H_T = [9I + 4I]C = 13IC_1 \qquad (7)$$

starting application. Load inertia is four times motor-rotor inertia, even though kinetic energy stored in the rotor is 225% of the load. Kinetic energy producing heat in the motor is the sum of that of the motor and that of the load. Using I for inertia, and substituting in Eq (4) to obtain Eq (6), the calculation is reduced and simplified to Eq (7). This shows, that despite its lower inertia, kinetic energy of the motor is 2.25 times that of the load, and is 69% of the total. If this motor is replaced by a 900-rpm unit with rotor inertia 2.5 times that of the original, and the same reduced load speed is maintained, kinetic energy of the rotor is cut to 5.625I; of the system to 9.6251—26% less than the 13I of Eq (7). Heat is reduced proportionately.

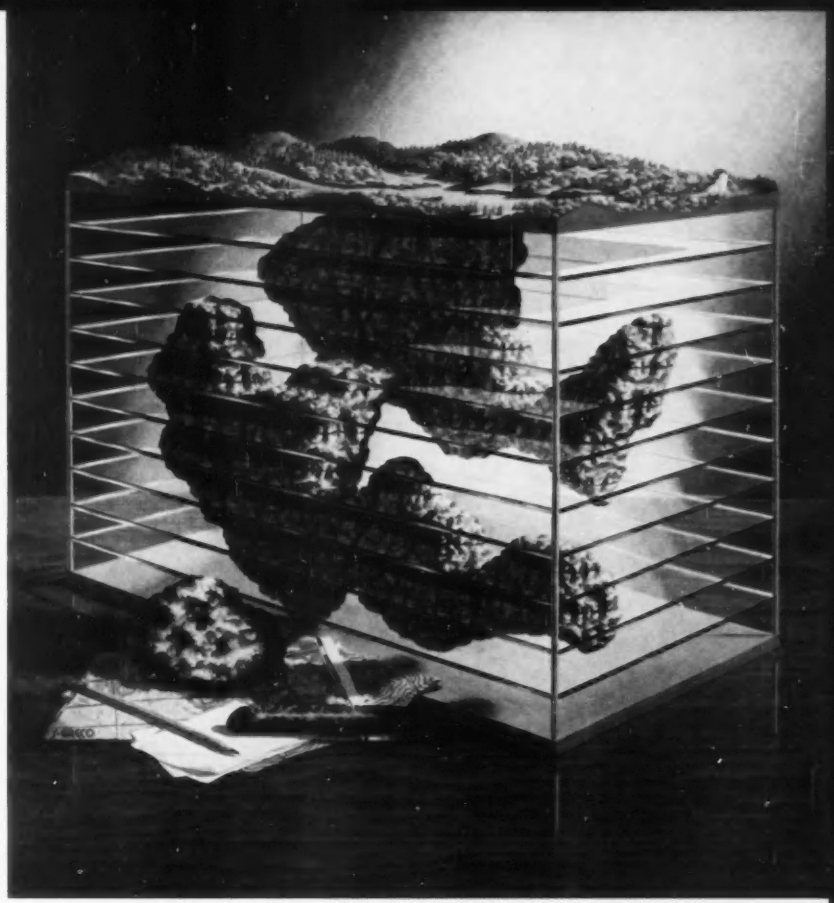
EDITOR'S NOTE: In addition to references cited here, the following articles evaluate factors in selection and application of machine tool drives.

Comparison between conventional NEMA motors and axial-air-gap high-inertia motors in "Axial-Air-Gap Motors for Machine Tool Drives" September 1955 page 129. Method of calculating the flywheel effect of motor rotors is included.

Detailed analysis of NEMA Design B, C, and D torque and speed ratings in "The Importance of Duty Cycle in Selecting Polyphase Induction Motors" November 1954 page 174. It also calculates various duty-cycle elements to satisfy drive requirements. In *Design Digest*, Mid-October 1953 page H24, starting characteristics of principal squirrel-cage motor types are given in "Significance of WK² and How to Calculate It." This article derives moments of inertia for various shaped parts and includes approximations for calculating WK² for flywheels, spur or helical gears, and motor rotors.

"A picture is
worth a
thousand words —

but a model is
worth a
thousand pictures."
—Henry Dreyfuss



MODELS SHOW HOW...

Built up on successive sheets . . .

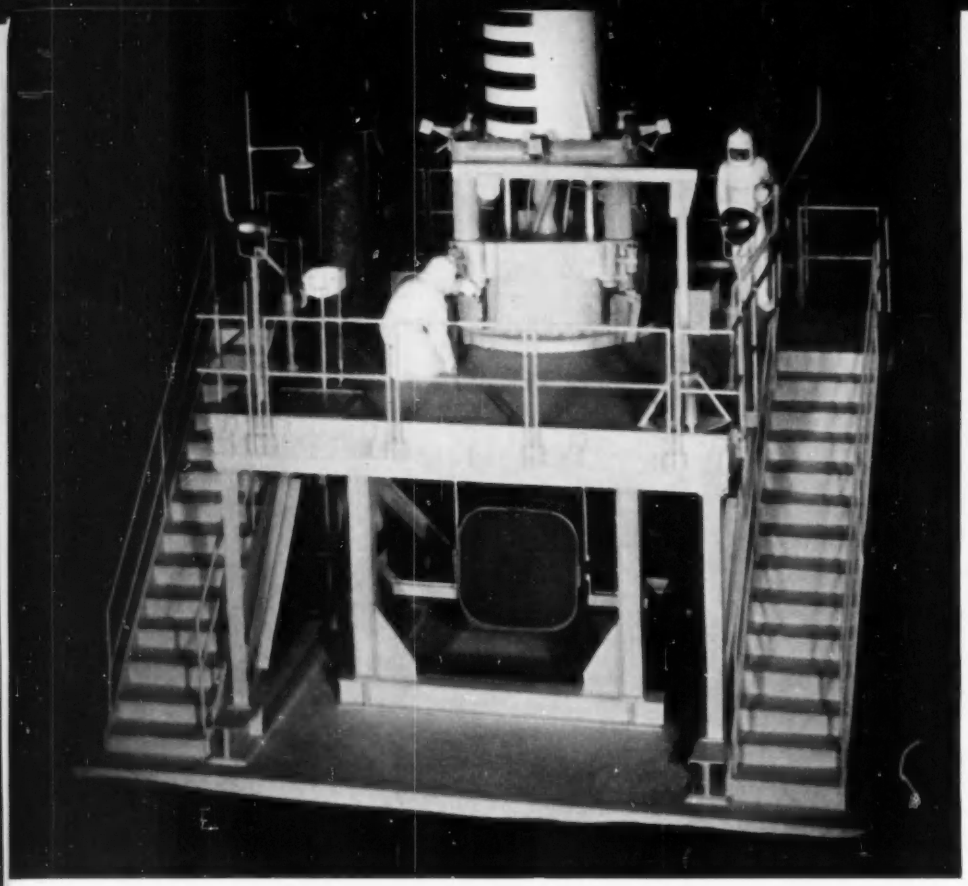
of glass or transparent plastic, irregularly shaped models may be made to demonstrate shape, materials and, if the layers are separable, cross-sections. The principle applies equally to faired housings, architectural structures, topographical studies, astronomy, ballistics and atomic theories. This three-dimensional ore body typifies models used by Inco mining engineers to help visualize and plan extracting procedures.

. . . your product works.

Made of plastic, wood, metal and clay, they will give your audience a "feel" for design ideas that no amount of description or sketching can duplicate. Painted in bright, contrasting colors, they graphically illustrate function, assembly and maintenance. And spatial relationships are seen "in the round."

To demonstrate what can be done in a medium as exciting to engineers as it is to all men, the editors have collected a group of photographs showing everything from nuclear reactors to extrusion presses, from rockets and missiles to a plastic bathroom.

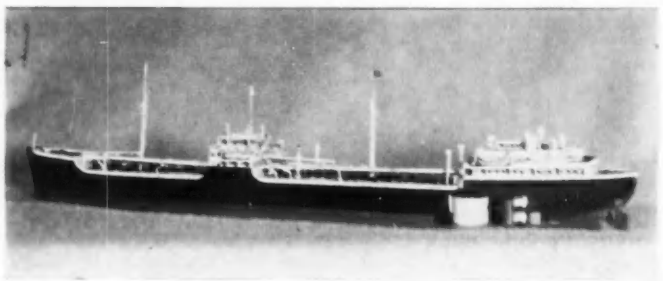
Here are dozens of ideas that saved thousands of dollars, hundreds of hours. With a little imagination, you can profit the same way.



Man's challenge to outer space comes alive . . .

in model of a satellite-launching platform and rocket stand designed, built and installed by Loewy-Hydropress, Division of Baldwin-Lima-Hamilton Corp., under subcontract with the Martin Co. The model is on display for the duration of IGY at the IBM Computing Center, in Washington, D. C.

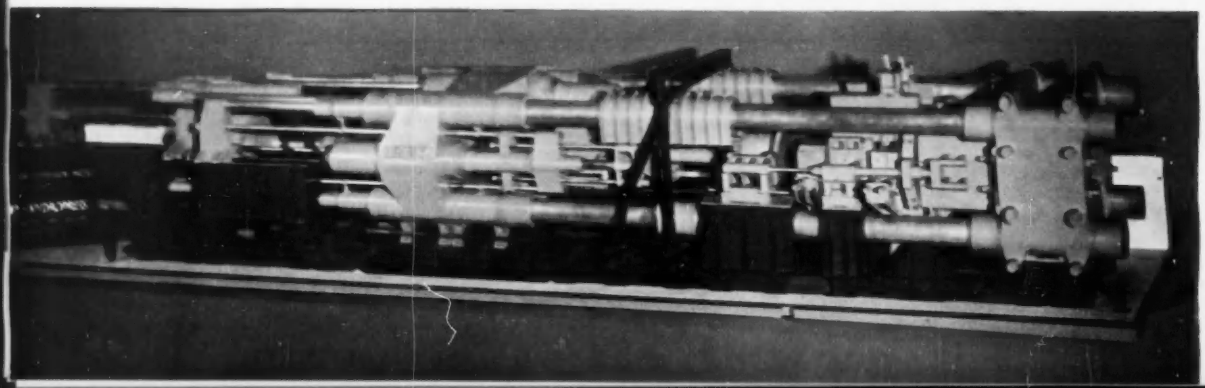
A store-bought ship model . . .

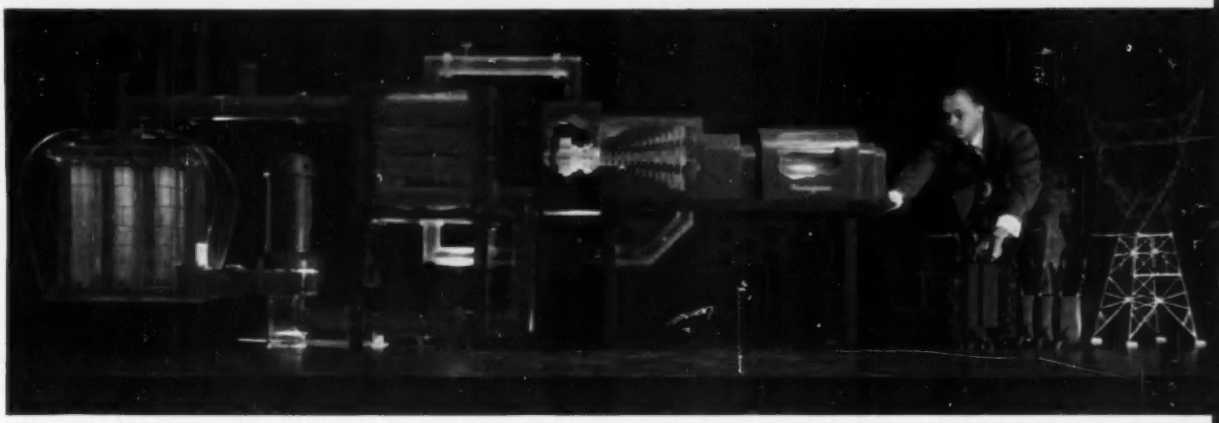


combined with hand-made propulsion system shows how a closed-cycle, gas-cooled nuclear reactor would look in the hull of a tanker. Ford Instrument Co., Division of Sperry Rand Corp. has been conducting studies for the AEC and the Maritime Administration on the feasibility of putting nuclear-powered propulsion into a 707 ft, 38,000-ton super-tanker.

Showing almost 5½ thousand tons of machine . . .

that couldn't be comprehended in drawings and specs, here's the model of a 20,000-ton extrusion press designed to dwarf any now operating. The press, engineered for the U. S. Air Force by Loewy-Hydropress Division of Baldwin-Lima-Hamilton Corp., was never completed because of cutbacks in the heavy-press program. Huge castings, now in moth balls, await a go-ahead.



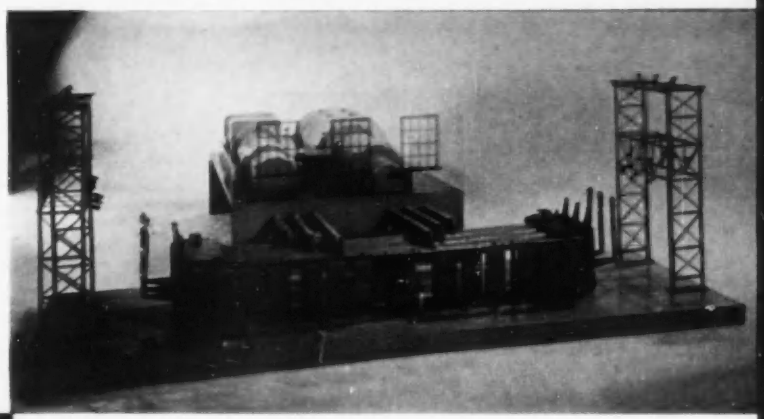


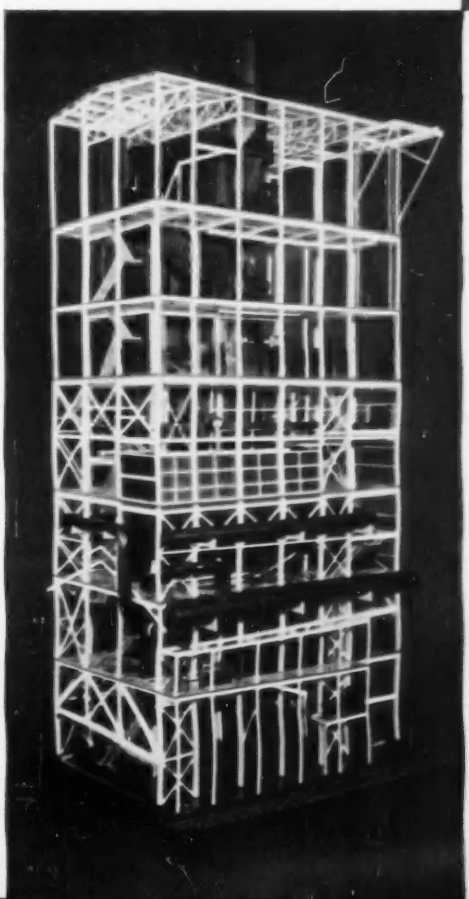
Reactor innards glow dangerously . . .

as this 12-ft model simulates flow of pressurized water through heat exchanger. Fresh water is converted to steam in the exchanger, then used to drive turbine and electric generator. Westinghouse Electric Corp. displays the model at trade meetings, conventions and assemblies.

Engineers show new cooling system . . .

with model of a dual hookup that connects each transformer to a generator of a close-coupled cross-compound turbine-generator unit. Here, the Allis-Chalmers Mfg. Co. model illustrates one of many arrangements in which all coolers can be used with either transformer.



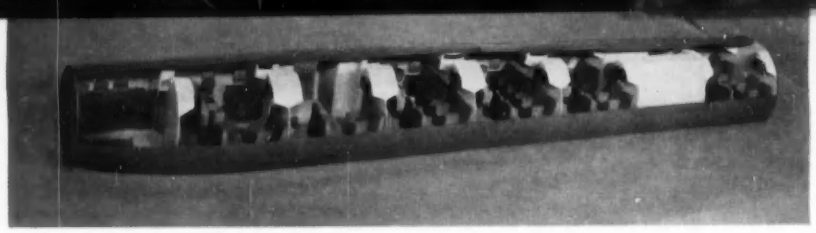


Discovery of 13 interferences and faults . . .

thanks to this model, saved some $100,000 in cost of constructing the power house. Such rewards easily justify the frequently high cost of modelmaking. Visual Plant Layouts, Inc., teamed with Rust Engineering Co. engineers for the presentation.

Progress in top-secret guidance systems . . .

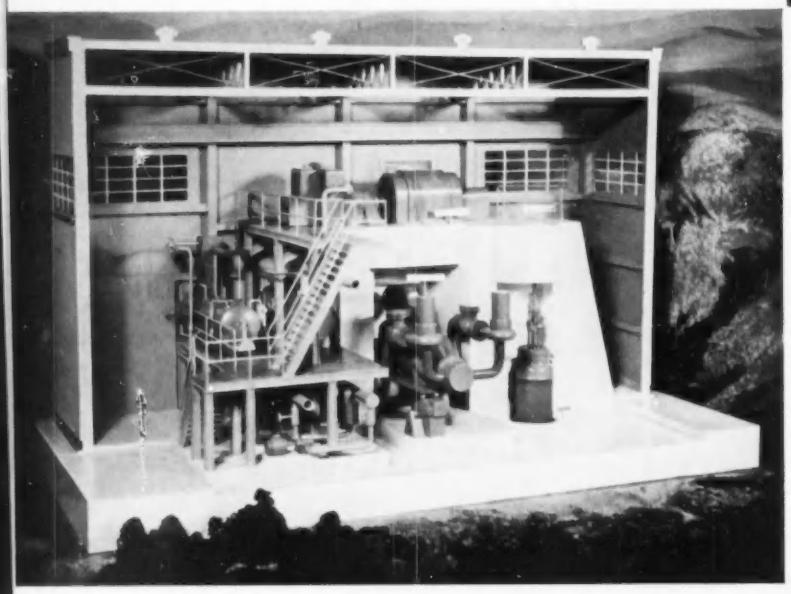
is exhibited at shows and conferences by this dramatic model of an Army missile. It was made by Ford Instrument Co. Division of Sperry Rand Corp., working with US Army Ordnance at Redstone Arsenal.



Seating arrangement . . .

in Lockheed's prop-jet Electra was worked out with this 1:16 model made by Henry Dreyfuss. Special 1:4 scale models, with interchangeable seats, curtains, carpets and other units are built to demonstrate colors and material texture. Seats are movable, held by magnets.

'MODELS are,

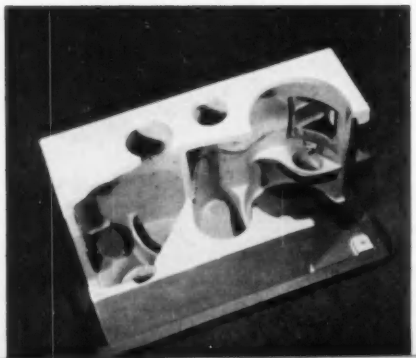


Designed for airlift . . .

this pressurized, light-water atomic reactor can generate several thousand kilowatts, sufficient for continuous operation of a remote mining camp or defense base during extended periods. Main advantage over conventional power plants is saving in fuel-handling costs. Model is used by American Machine & Foundry Co. designers.

Final design of tire tester . . .

developed by Cornell Aeronautical Laboratory, Buffalo, stands out in this colorful model illustrating load cells, wheel frame and trunnion. Tester measures six components of force and moment.



Difficult to imagine, impossible to draw . . .

curved surfaces like the ones in these experimental bathrooms didn't faze the modelmaker. The real bathrooms are almost entirely plastic, with two large shells forming walls, ceiling and floor. Plaster models helped in development, and fabricators used final models in molding and assembly. Transparent plastic figure of man indicates scale. Henry Dreyfuss designed the bathrooms for Crane Co., cooperating in development of Monsanto's House of the Future.

more and more often, the one best way to keep everybody thinking straight'. . .

. . . says one Midwest chief engineer, "The number of men, many not engineers, involved in discussions and decisions, both here in our plant and when we're talking to customers, is growing steadily. Also, while we pride ourselves on being able to read blueprints, the models are easier and faster to use, and prevent errors. We use models to show principles, details, mechanisms, operational techniques, over-all appearance—and to picture clearly to others what we have in mind. The types and ways of making models vary with the application, and every model we make ends up by developing some new application for itself."

There, in a nutshell, are the basic reasons why models like those pictured on preceding pages are becoming so popular. They're not toys, or the aftermath of the recent 3D craze; they're worth their cost (which is usually a lot more than anybody expected—one oil-refinery piping model cost $40,000, but saved its cost four times over on the first job).

Commonest model is the 3D plant layout, with miniatures of equipment in place. Parts for such models are now available from a number of companies, to either ⅛ or ¼ in./ft scale. Such setups exemplify many of the advantages of all models—the ease with which interferences, bottlenecks, safety hazards, poor access and the like can be spotted. Components are readily available—machines, racks, rails, and particularly people in various poses. In fact, if a model is to incorporate "people" or "operators," the scale is best at ¼ in./ft, because scale model-railroad figures are available.

Large models and mockups are frequently of wood and clay, produced by plant patternmakers, because of ease of building and change. But detailed and smaller models are more and more commonly of plastic because of permanence, non-warping, good color, and ease of assembly by cementing. Boat, railroad, and other hobby-model parts can often save time and aggravation.

TYPES OF MODELS

In addition to the familiar plant-layout model, a number of companies use models of single processing lines: some made in extreme detail for plant use, others merely for spectacular exhibits. Occasional models actually show buildings and grounds, and have sections of buildings removable to reveal plant layout. Such setups are often made on gridded plastic, so that vertical photographs can be taken to show actual layout at a given time, proposed changes, and the like.

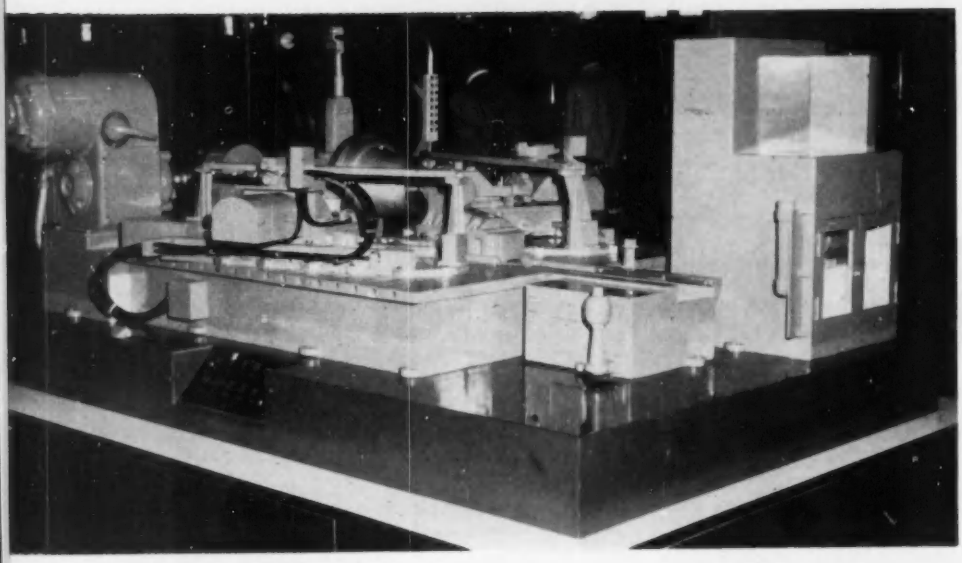
A second type of model is the take-down unit from which various segments can be removed to show the interior. These are usually to fairly large scale, and may be of machines, mechanisms, components or even such details as valves and fittings. They are used in training, demonstration, explanation, and in selling.

Design principles are demonstrated by movable models which may be simple lines and outlines to delineate areas or may be extremely detailed, with working parts made of metal or transparent plastic. A variant is a combination of a drawing or layout with 3D elements mounted on it. Another type is, of course, the working model which simply utilizes scale to make the machine or mechanism portable or easily comprehensible. Some, worked out in tremendous detail, have been extremely helpful in studying what actually happens under operating conditions.

Also quite common are prototypes for appearance design. Built of wood and modeling clay, they are designed principally for achieving good appearance, but some may incorporate alternate arrangements and accessory setups to be sure that the changes or special elements being planned are practical and operative.

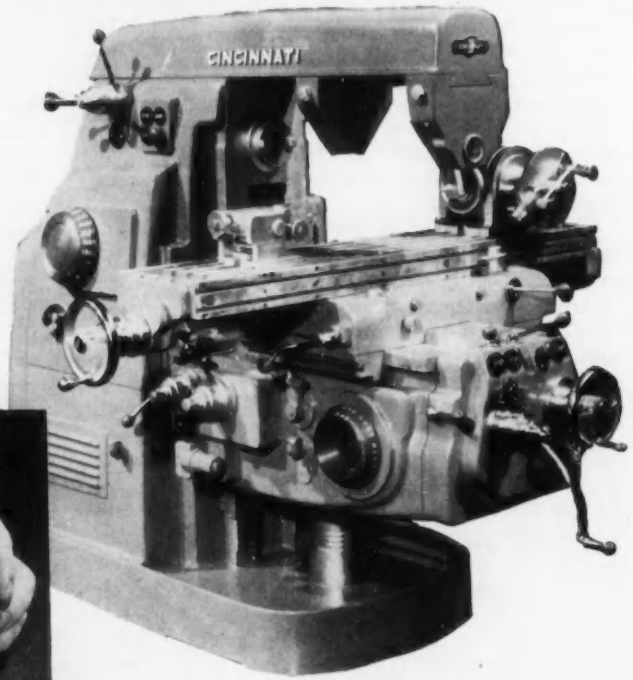
WHERE MODELS COME FROM

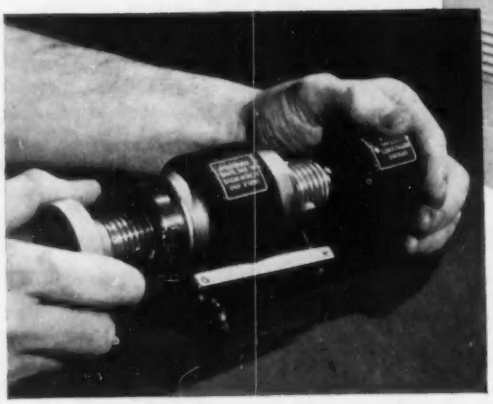
Many working models are produced by men in a given plant—either in its engineering department or the shop—and are frequently done as spare-time projects. Such models are commonly of wood and metal, although some begin to incorporate plastics and specialty materials. There are also a number of modelmaking firms of various types; some competent to make working models and provide design suggestions, others largely makers of display models. Usually such suppliers will furnish an estimate of costs after personally making sketches or photographing the material that is to be the basis of the model. For example, the price for 3D layouts for a plant run 2 to 7½ cents per sq ft, depending upon degree of detail, congestion and types of equipment incorporated. (*next page, please*)



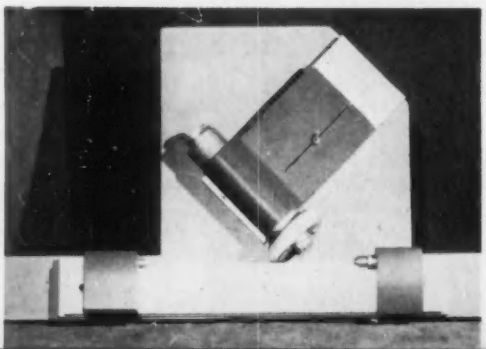
New principles . . . can be broadly demonstrated faster with working models. This model of a Cincinnati Hydrospin machine will operate under pushbutton control, but does not make parts. It is largely of wood, serves for both development and display.

Working models of machine mechanisms . . . demonstrate interesting or difficult points. The "backlash eliminator" (below) shows (and permits the user to feel) backlash between leadscrew and nut on a Cincinnati knee-and-column miller.

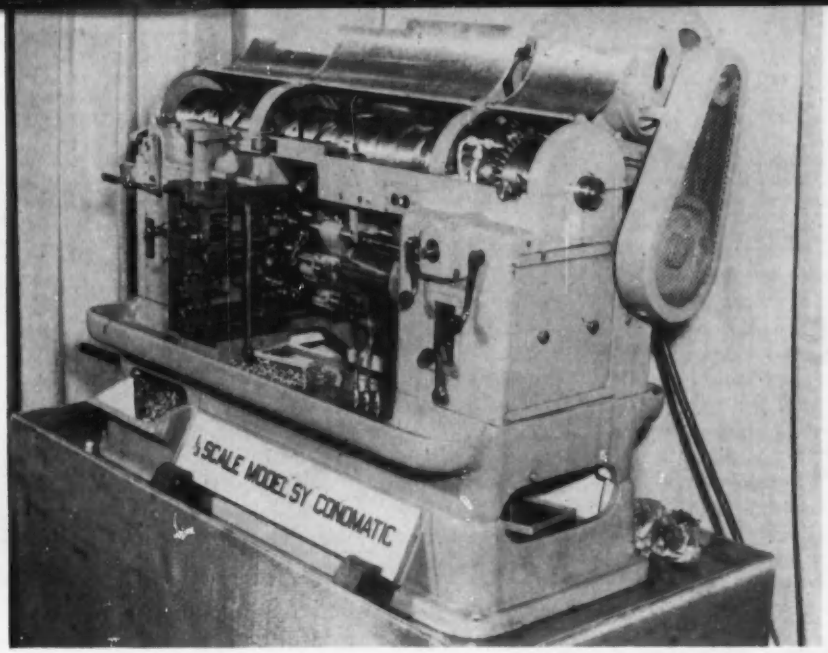




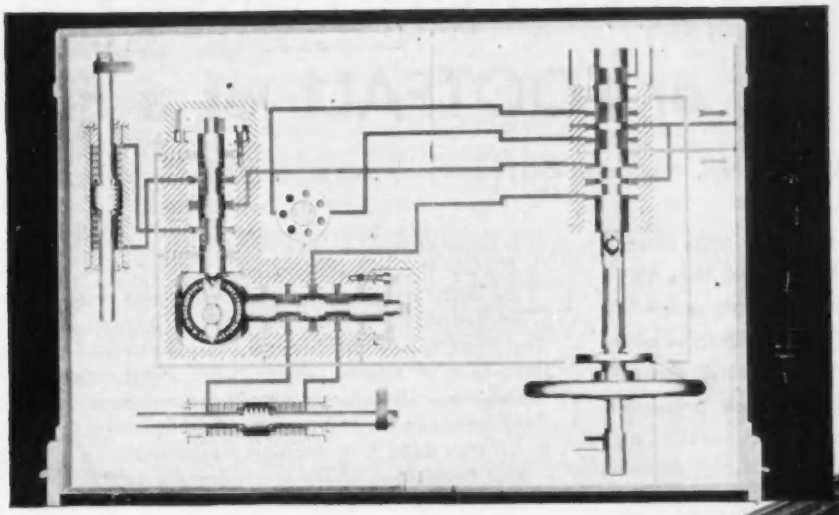
Mockups look real . . . full-size automotive and aircraft mockups are common, but here's one of a machine tool. It is mostly wood, was used in engineering and sales conferences. Major components can be quickly disassembled to show features. Handwheels, control knobs and levers are actual parts for realism.



Design principles . . . are demonstrated by this movable model of a Cincinnati adjustable angular wheelhead for a grinder. Wheel-mounting methods and clearances with worn wheels can be shown.

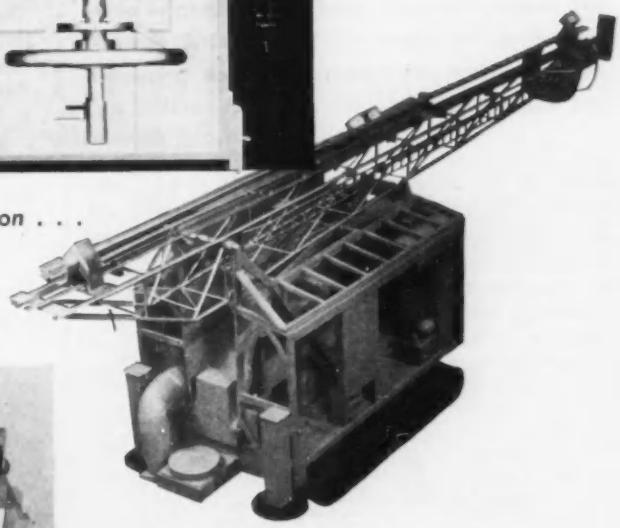


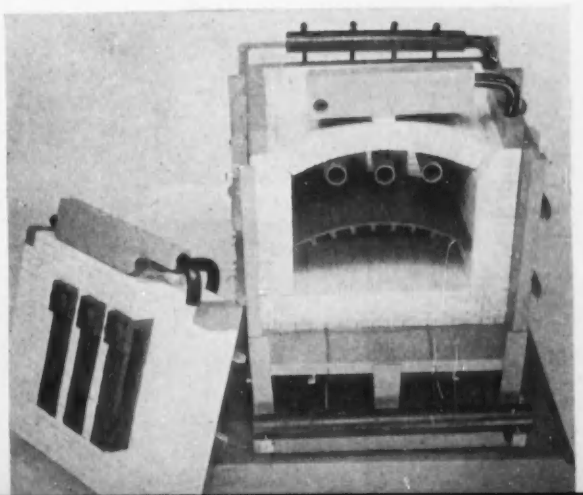
Working models built to scale . . .
are costly, but may help study and understand a complex machine. This model of a 6-spindle automatic lathe was made to ⅓ scale, required 2200 hours of spare-time labor (at 20 hr per week). An employee of Cone Automatic Machine Co. produced it to scale from regular prints. It's used in technical meetings, at schools and in shows; makes small, brass screws



3D ports and valves . . .
here are set against a 2D diagrammatic panel of an entire hydraulic circuit. Valves and ports are operable for demonstration. An unusual idea is the use f rotatable and interchangeable background panels to show variation in circuits.

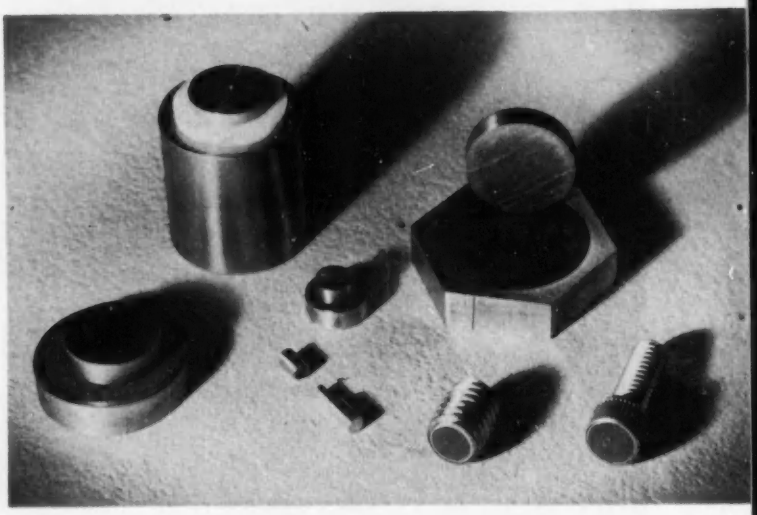
Removable sections simplify interior examination . . .
of this recuperative-atmosphere furnace. Normally, firebrick would hide the interior. This model was made at home by a design draftsman for Lithium Co.





Jet piercing machine . . .
by Linde Air Products. Hydraulic operation made a crowded maze of pipes, valves, pump and electrical controls. Engineer and industrial designer cooperated to produce a functional placement of equipment by working with schematic layout and model. Actual machine was piped by a hydraulic engineering company for $2000 less because of the model.

Plastic wafer . . .
of intermetallic resin converts force to an electrical control signal. Largest cell, upper left, is able to take 15,000 psi.



PRESSURE-SENSITIVE MATERIAL MEASURES EXPLOSION FORCES . . . or FOOTFALL of a FLY

DUDLEY B. CLARK, *Director, Clark Electronic Laboratories, Palm Springs, Calif.*

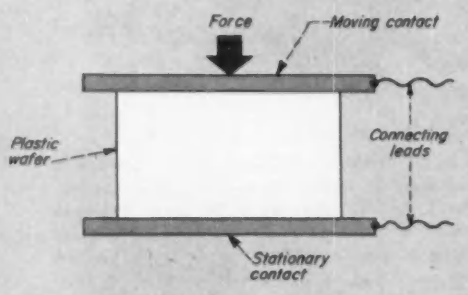
Pressure cells made from the rare earths change electrical resistance when compressed, thus serve as force transducers. Because of high sensitivity and output, they don't need amplification to operate relays, recorders and other control devices. Here's the first complete rundown on properties and application data.

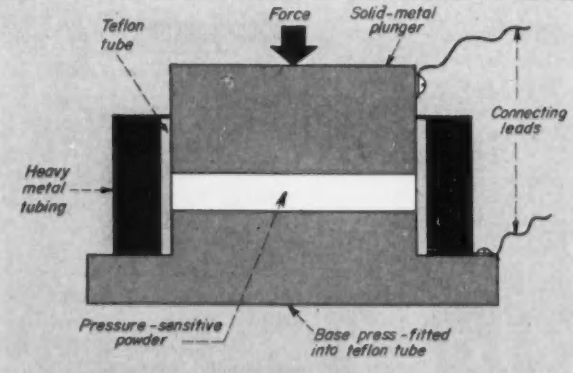
Intermetallic resins open the door wider to a versatile technique both for measuring forces and pressures, and for controlling them. The method is based on the electrical-conductivity variations possible in pressure cells incorporating these sensitive materials. Produced by processing rare earths with zirconium tetra-chloride, such resins undergo a large change in electrical resistance when they are compressed.

The cells are usually a long-lived plastic wafer or pellet bonded to a recess in brass or stainless steel. They react to any quantity that can be converted to a force—such as tension, strain, displacement, velocity, acceleration, vibration or rotation. They range from shock ratings of 250,000 psi for testing explosives, down to less than 0.001 gram for biological research.

This broad span—ability to measure an explosion or the footfall of a housefly—is one advantage, but there are others. Along with high sensitivity, the cells have high output, eliminating the need for amplifiers when

Basic forms . . .
for press re cells; sandwich, left, and pressure-sensitive powder, right





selecting them to operate relays, recording instruments and other controls. And they can be applied to surfaces of any shape or contour.

The simple construction of these cells—two electrical contact surfaces with the sensitive material between them—gives almost unlimited flexibility in application. The resin also comes as a pressure-sensitive paint. Metals can be dipped in it, or sprayed. When dry, the paint can be covered by a conductive surface deposited in vacuum or applied with conductive paints. Or, for high-pressure cells, a sensitive powder will serve.

Most standard brass cells can be press-fitted, soldered, or clamped in place. Stainless-steel studs require a threaded hole. Cells can be manufactured with characteristics accurate to within 0.25% of each other. There is now also an all-plastic cell that needs no metal contacts.

Cell versatility arises from both the ultra-wide range of forces they can measure and areas they can cover. More than 27 compositions of sensitized plastic have been developed for over 300 types of standard cells. There is basically no upper limit to size—cells a foot square have been fabricated. Minimum area on which a load can be applied is 0.001 mm^2; one such ultra-miniature cell fits inside a hypodermic needle used for sensing intramuscular pressures.

High sensitivity is the result of an exceptional increase in relative resistance as no-load pressure is approached. This ranges from about 15:1 for cells with a no-load resistance in terms of ohms, and over 3,000,000:1 for cells with maximum resistance of 100 megohms or more, as shown in the table. Maximum resistance and change in resistance with load are regulated during manufacture by a heat-treating process; values beyond those in the table on the last page can be produced. High outputs are directly obtainable without complex and expensive amplifiers. For example, a cell rated at 30-ohms minimum change will, with 6 "v" applied, pass less than 0.2 amp at no-load but 3 amp with full-load force of 2 lb. This is more than enough current to operate standard relays or other industrial-control equipment requiring high current inputs, also allows them to be used as contactless contactors.

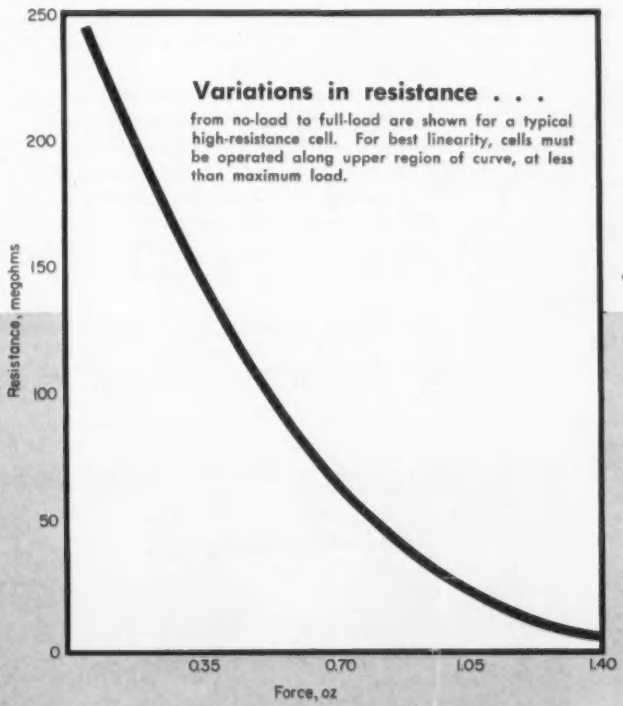
Where direct operation of relays or other control devices is not desired, high-resistance cells are the answer. They will control high-impedance devices such as thyratrons and vacuum tubes; can also supply input control signals for magnetic or transistor amplifiers.

Hysteresis presents a negligible problem. The low-pressure cells withstand a minimum of 100% overload. High-pressure units stand 2,000 psi over their normal rating. Compression of low-pressure cells under load is negligible; high-pressure cells compress slightly. For example, a 10,000-psi cell is compressed a maximum of 0.007 in. at full load. Hysteresis for all units is normally less than 2%. To reduce hysteresis and increase stability in the region of zero pressure, the cells should be preloaded to about 5% of maximum force rating. One method is to use relatively heavy contact.

Because these cells have no moving parts, they can withstand high vibration and shock. Tensile strength is somewhat limited, but proper design of the cell and proper initial processing can substantially overcome this limitation. In ambient atmospheres of high humidity, the cells must be sealed against moisture. They can be operated immersed in oil, without injury.

ELECTRICAL CONNECTIONS

Such cells require only two electrical connections. The base is one terminal; the other is a top conductive



Variations in resistance . . .

from no-load to full-load are shown for a typical high-resistance cell. For best linearity, cells must be operated along upper region of curve, at less than maximum load.

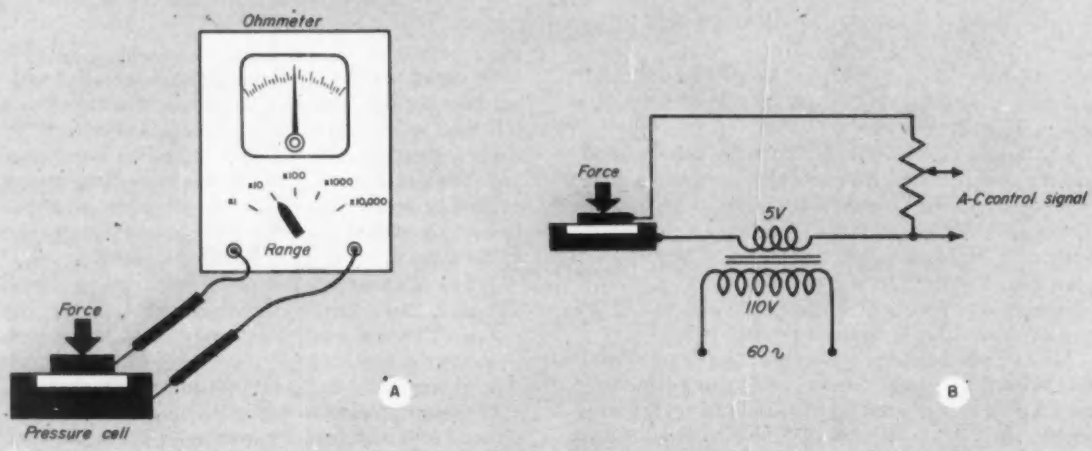
Those Curious Intermetallics

Intermetallic compounds are, surprisingly, just that—combinations of metals within an alloy system: They behave like chemical compounds instead of like alloys.

Some are simple, others incredibly complex. By 1920, almost 400 confirmed compounds were known; today this figure is much higher. Research since 1920 has revealed that three basic factors control the formulation of intermetallics: atomic diameters of the constituent metals, electrochemical effects between them, and the electron structure of each.

Present excitement about intermetallics stems from this greater knowledge and recent refinements in making them. Some have suitable semiconductor properties.

Researchers are probing many potential industrial uses: jet engine materials, metal-ceramic brazing compounds, transistors, refining crucibles for reactive metals like titanium. Presented here is just one of the new applications invented by Dudley B. Clark and involving an even stranger breed—rare earth intermetallics. More details in a coming issue.



coating such as vacuum-deposited silver, or solid metal of the proper shape for uniform contact over the desired cell area. Mercury may serve as an upper terminal, but only in vacuum—to prevent mercury contamination. The upper contact for standard cells is a thick circular piece of brass polished to distribute pressure evenly over the contact surface.

One of the contacts, usually the upper, must be insulated—phenolic-plastic laminates or Teflon are suitable. Where two irregular contours mate, thin flexible insulating material can be used.

Either a-c or d-c voltages ranging from millivolts to 500 v can be applied to these cells. The maximum is limited primarily by the maximum allowable cell temperature. Excessive current increases cell temperatures above rated limits and decreases cell sensitivity. The wattage rating for any cell can be increased by addition of a heat sink, or other improvement in heat dissipation. Although 10 w is maximum for standard cells, special units have been produced with ratings of several hundred watts.

To boost both sensitivity and voltage rating, cells can be stacked and connected in series. This increases ratio of minimum to maximum current, but magnitude of current flow is decreased. Connecting stacked cells in parallel improves accuracy by averaging out differences, but also increases current flow.

TEMPERATURE RESPONSE

When operated within rated temperature limits, the effect from a temperature change is small. For example, for standard 300-F cells there is less than 0.5% resistance variation from approximately −20 F to 300 F. As temperature increases above this limit, sensitivity decreases until a maximum usable operating temperature is reached at 500 F.

Special cell processing can extend this limit to 600 F. Can the cell be destroyed by excessively high temperatures? This depends upon the metal. The cell plastic itself can be heated to 1000 F without damage. Upon cooling, original sensitivity and resistance of the cell will return.

DYNAMIC RESPONSE

With standard cells the dynamic response is, in general, limited to approximately 60 cycles, but by special processing, it can be increased to 400 cps or substantially higher. For example, stainless-steel studs have a response up to 3,000 cps.

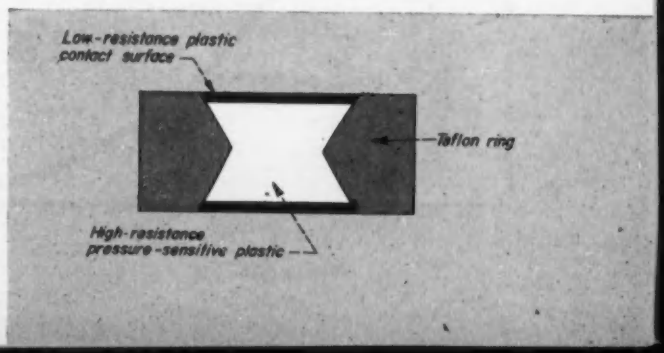
The pressure cells are essentially a pure resistance and have negligible inductance, allowing their use with voltages of carrier frequencies. However, as the frequency of applied voltage is increased, the electric capacitance between the upper and lower contacts becomes significant, particularly in the larger sizes.

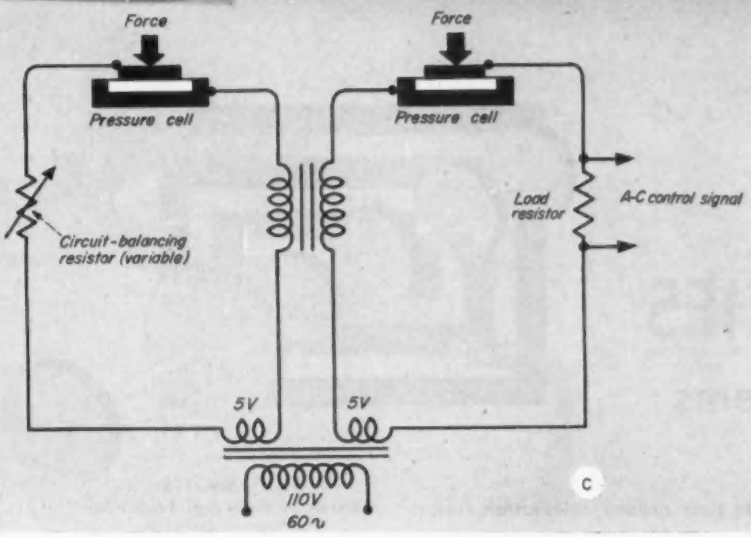
For calibration or tests of slow pressure or force variations, an ohmmeter, with ranges matching the cell resistance, is a simple and reliable indicator. Accuracy of the reading depends upon that of the instrument used. To obtain a reading, the ohmmeter terminals are connected to the two pressure-cell contacts. If desired, the ohmmeter scale can be replaced with one calibrated to read in units of the pressure or other quantity being measured.

When pressure changes are faster than a few cycles per second, the cell output may be applied to a recording instrument or suitable oscilloscope without further amplification.

Latest type cell, . . . ▶

with no metal in its design, has low-resistance plastic for upper and lower contact surfaces and Teflon for supporting sides. Presently available size is 1-in. OD by ¼ in. thick. Two cells mounted back-to-back can be connected in a bridge circuit to cancel the effect of ambient vibrations, thus measure static force directly.





Typical circuits . . .

for testing output of cells (A) and putting their sensitivity to work in a direct measurement (B) or to measure differences in forces (C). Control signals may operate relays, amplifiers, recording equipment.

EDITOR'S NOTE: Previous articles have described other types of tranducers useful in product design development and for control.

Three articles on the application and design of strain-gage bridges appeared in 1956. They are: "Strain Gage Balancing Simplifies Multiple Bridge Measurements," June, p. 161; "Strain Gage Transducers," March, p. 196; and "Strain Gage Bridge Sensitivity Control," Jan., p. 200.

"Pressure Transducers," Jan. '54, p. 174, discusses the application of resistance strain gage, capacitance, piezoelectric, and reluctance-type transducers for pressure measurements, with emphasis on high-temperature transients. Advantages and disadvantages of each type.

"Strain Gage Transducers for Measurement and Control"—a 28-page special feature, Nov. '52, p. 121—is a comprehensive article on resistance strain gages. The first section describes bonded and unbonded gages, types of bridge circuits, amplifying and recording equipment, and systems combining these components. Remaining sections discuss various types of strain-gage transducers used for measuring pressure, flow, weight, and displacement. Case histories are included.

"Ready-Made Amplifiers for Transducer Signals," Sept. '51, p. 143, explains advantages and methods of using standard temperature controller-recorders as transducer-signal amplifying and recording instruments. Summary of transducer characteristics for acceleration, motion, speed, radiation, density, pressure, humidity, frequency, force, weight, temperature, radiation, current, and power-sensitive measurements is included.

Typical Characteristics of Standard Pressure-Sensitive Cells

		Size of Cell, in.		Force Range, lb	Cell Resistance, ohms		Max Allowable Dissipation, watts
		Outside Dia	Thickness		Min Change for Force Range Indicated	Min Value at Max Force	
Low-pressure Cells	Press-fit, Soldered, or Clamp-mounted	0.125	0.187	0–1/2 0–5	30 10^5	2 7,000	1/4
		0.25	0.25	0–1	30	2	1/2
		0.50	0.125	0–2 0–5	600 10^6	40 7,000	1
		0.75	0.25	0–10	10^8	10,000	5
		1.25	0.25	0–2 0–50	30 10^6	2 7,000	10
		Thread Size	Length				
	Stud-mounted	8/32 10/32	3/4 1/2	0–1 0–2	30 600	2 40	1/2
		1/4–20 5/10–18	3/4	0–5 0–10	10^6 2.10^8	7,000 10,000	1
		3/8–16	1/2	0–50	10^6	7,000	2
		Outside Dia	Thickness	Psi Max			
High-pressure Cells		1.0	1.00	1,200 3,000	3,000 15,000	7 50	5
			1.25	6,000 9,000 15,000	10^6 10^6 10^6	1,600 50 30	

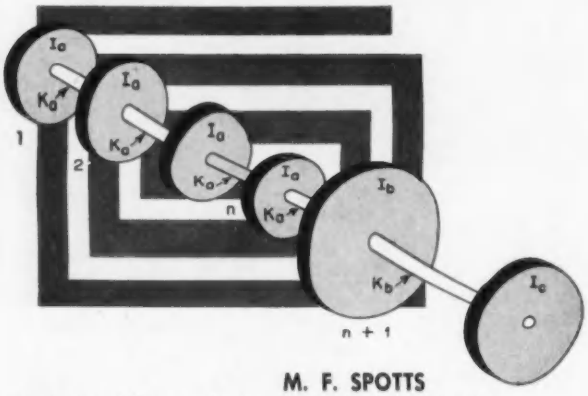
Typical Applications of Pressure Cells

Measurement of:
- Vacuum or gas, 5 microns to 5 atm
- Physiological pressures
- Explosion or shock forces
- Tension or strain
- Hydraulic pressures
- Differential pressures
- Wind-tunnel pressures
- Instantaneous pressures in engine ignition chamber
- Magnetic-field strength
- Pressure on surfaces of aircraft propeller blades
- Pressure on bearing surfaces of gas-lubricated bearings
- Acceleration

Control of:
- Pressure on heavy press rolls
- Reeling tension of cloth, paper, thread or wire
- Pressure-balancing bridges
- Sorting by weight
- Engine speed
- Ball-bearing preloading

Other:
- Dash-board tire-pressure indicators
- Contactless ignition-timer points
- Contactless contactors
- Engine oil-pressure indicator (immersed in oil)
- Hydraulic-fluid leak detectors

shortcut to CRITICAL FREQUENCIES of torsional systems



M. F. SPOTTS
Professor of Mechanical Engineering
Northwestern University

How to obtain quick approximations that reduce calculation labor.

Trial-and-error is the widely used—but time-consuming—way for finding the critical or "natural" shaft frequencies in design of torsional systems with three or more masses, such as crankshafts in diesel and internal combustion engines. Here is a shortcut that reduces computations for a frequently occurring system where all masses but two, and all shafts but one, are identical.

The time-saver gives first-approximation values for critical frequency that will often satisfy accuracy requirements. For more precise work the approximations can be substituted into Eq (1) which is the basic formula for critical frequencies of this system. A non-zero result indicates that the factors must be modified by the usual trial method until the equation is satisfied.

In Eq (1), derived from recursion formulas in *Vibration Problems in Engineering*, (Timoshenko, page 254, D. Van Nostrand Co., 2nd edition, 1937), the amplitudes α_a and α_b depend on critical frequency p and the number of I_a disks in the system. To develop these relationships it is customary to set the amplitude of the first disk as unity. Then Eq (2) gives the amplitude for the second disk, etc. When I_a is small compared with I_b and I_c and k_a is large compared with k_b the lowest critical frequency can be approximated by assuming a two-mass system in which the I_a and I_b disks are represented by a single disk I_x. Eq. (1) then simplifies to Eq(3). This approximation is then tried in Eq (1) to check its accuracy. If Eq (1) is not satisfied, trial-and-error will give the desired value.

HOW THE SHORTCUT WORKS

Consider a system with four equal disks $I_a = 4{,}000$ and two other disks $I_b = 30{,}000$ and $I_c = 10{,}000$. Stiffness of the uniform shafts is $k_a = 100{,}000{,}000$; for the remaining shaft $I_b = 4{,}000{,}000$. Substituting these values in Eq (3) gives

$$p^2 = \frac{4{,}000{,}000 \times 56{,}000}{46{,}000 \times 10{,}000} = 487$$

Amplitudes α_a and α_b can now be computed using this approximate value for p and substituted in Eq (1) with p to check the accuracy of the approximation. Since $n = 4$, α_a becomes α_4 and α_b becomes α_5. In this example, the value of 487 for p^2 is not satisfactory, and by trial and error a better value of 482 is obtained.

For the second fundamental mode, a trial value for p^2 is obtained by grouping the four disks into a single disk $I_x = 16{,}000$, located at the center of the four sections of k_a shafts. Since the assumed shaft is twice as long as one of the actual sections, the stiffness k_x is cut in half, or 50,000,000. Now applying Eq (4) (from page 255 of Timoshenko) gives

$$p^4 - 5{,}325\,p^2 + 2{,}333{,}300 = 0$$

from which $p^2 = 4.843$

After computing α_4 and α_5 and applying the above value for p^2 in Eq 1, trial and error leads to 4,405 rad/sec.

Critical frequencies p of the system in rad/sec, can be obtained from

$$p^4 + \left[\frac{k_a}{I_b}\left(\frac{\alpha_a}{\alpha_b} - 1\right) - \frac{k_b(I_b + I_c)}{I_b I_c}\right]p^2 - \frac{k_a k_b}{I_b I_c}\left(\frac{\alpha_a}{\alpha_b} - 1\right) = 0 \quad (1)$$

where I=moment of inertia of a disk, lb-in-sec^2 (in internal combustion engines, the cylinders are approximated by a series of identical disks); k=torsional stiffness of a shaft, in.-lb/rad; and α=torsional amplitude of a disk, rad (α_a=amplitude of nth disk and α_b the amplitude for I_b disk).

Values for the amplitudes can be obtained from this series of equations

$$\alpha_1 = 1$$
$$\alpha_2 = \alpha_1 - \left(\frac{p^2}{k_a} I_a\right)\alpha_1 = 1 - Q \quad (2)$$

where $Q = p^2(I_a/k_a)$

then
$$\alpha_3 = 1 - 3Q + Q^2$$
$$\alpha_4 = 1 - 6Q + 5Q^2 - Q^3$$
$$\alpha_5 = 1 - 10Q + 15Q - 7Q^3 + Q^4$$
$$\alpha_{n+1} = (2 - Q)\alpha_n - \alpha_{n-1}$$

Values for p in Eq (1) are not easily solved—hence the use of trial-and-error methods. For quick approximation of the first critical frequency,

$$p^2 = \frac{k_b(I_b' + I_a)}{I_b' I_a} \quad (3)$$

where I_b' is the sum of all the I_b and I_b disks. The second natural frequency can be approximated from

$$p^4 - \left[k_b\left(\frac{1}{I_a} + \frac{1}{I_b}\right) + k_x\left(\frac{1}{I_a} + \frac{1}{I_b}\right)\right]p^2 + \frac{k_x k_b(I_x + I_b + I_a)}{I_x I_b I_a} = 0 \quad (4)$$

Titanium cladding . . .
on steel strip withstands 90° and 180° bends in both tension and compression without damage.

TITANIUM-CLAD STEEL sooner than you think

Industrial exploitation of titanium's excellent corrosion resistance is limited, to date, by high cost; however, roll-cladding steel with a thin layer of titanium may offer a low-cost solution. Here is a progress report on adapting an old technique to this important new problem.

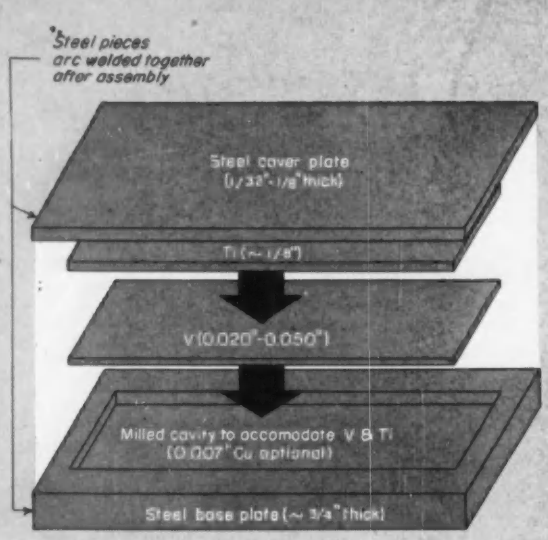
R. F. Domagala, D. W. Levinson, W. Rostoker
Armour Research Foundation

Recent research on roll-cladding titanium on steel has solved the problem of providing a ductile bond between the two. A formable clad material using these two metals has heretofore eluded investigators because of brittle compounds which form in the interface area. By interleaving the titanium and steel with thin sheets of vanadium and copper, a cladding can be produced which will withstand severe forming, as shown above, without damaging the bond. Summarized here are two basic methods of laminating, conditions of rolling, the nature of the bond, and remaining obstacles to commercial exploitation of the process.

The idea of cladding one metal on another is not new; metal composites have been used for many years in such applications as thermostats, relays, journal bearings and pressure vessels. Such metal combinations can be prepared by any of several techniques, simple soldering or brazing perhaps being the most obvious. Roll-cladding is also well-established. Here, the desired metals are assembled, heated, and rolled until bonding is accomplished by pressure welding. The principal variables in roll-cladding are temperature of rolling and per cent reduction of the initial laminate.

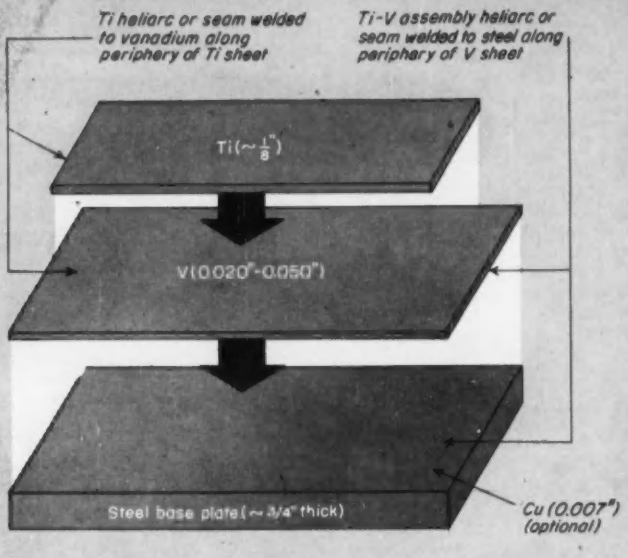
INTERMETALLIC COMPOUNDS CAUSE TROUBLE

Direct roll-cladding of steel onto titanium produces a product of limited usefulness because diffusion between titanium and iron forms intervening layers of intermetallic compounds or phases. Presence of these brittle compounds at the bi-metal interface limits bend ductility of the clad, which in turn limits fabricability and subsequent permissible operating conditions. The probable occurrence of such brittle compounds in any metal composite can be predicted from the phase


*Steel pieces arc welded together after assembly
Steel cover plate (1/32"-1/8" thick)
Ti (~ 1/8")
V (0.020"-0.050")
Milled cavity to accomodate V & Ti (0.007" Cu optional)
Steel base plate (~ 3/4" thick)

1 Milled-cavity technique . . .

After rolling, coverplate is removed by milling or acid-dipping to expose clad titanium surface.


Ti heliarc or seam welded to vanadium along periphery of Ti sheet
Ti-V assembly heliarc or seam welded to steel along periphery of V sheet
Ti (~ 1/8")
V (0.020"-0.050")
Steel base plate (~ 3/4" thick)
Cu (0.007") (optional)

2 Welded-sandwich technique . . .

Preliminary bonds are formed by welding sheets to each other prior to rolling. Coverplate is not necessary.

diagrams for the adjoining metals. The extent of their occurrence depends on the times spent at elevated temperature during preheating, annealing and later service.

A THIRD MATERIAL NEEDED

Theoretically, the presence of compounds can be circumvented in cladding titanium on steel if a third metal is interposed between the two. This third metal must be completely compatible with both steel and titanium, that is, it must not form compounds with either. A review of the periodic table and the known relationships between the elements Ti-X and Fe-X leads to the choice of vanadium as the best candidate. No intermetallic compounds form between titanium and vanadium and only an intermediate, semi-stable phase exists in the V-Fe system.

Further refining the metal relationships: If a thin layer of copper is placed between the vanadium and the steel, no compounds should be formed at any interface. If a composite of these metals is formed, it is titanium bonded to vanadium, bonded to copper, bonded to steel, rather than simply "titanium-clad steel."

PRACTICAL METHODS

At this point it is necessary to leave theory, and investigate practicability of uniting the metals into a useful product. Because of the reactivity of the metals, particularly titanium and vanadium, with air at the rolling temperatures necessary to cause bonding, preliminary bonds are necessary to prevent air from entering an assembled compact.

Many compact assembly techniques are possible; two successful experimental methods which may be developed further commercially are the milled-cavity technique, Fig. 1, and the welded-sandwich method, Fig. 2. Thicknesses of the components shown in these figures are arbitrary and can be varied according to the Ti/steel ratio desired in the finished product.

Although the optimum thickness of vanadium has not been established, experimental work using vanadium sheet of thickness varying between 0.020 and 0.050 in. yields sound clads. It is probable that thinner material can be employed successfully. Size of the assembly is governed by the rolling facilities available and the furnace size because reheating between rolling passes is necessary.

CLEANLINESS IS ESSENTIAL

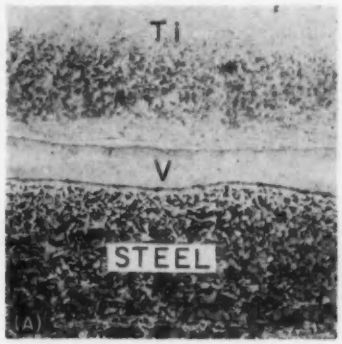
Where the initial bond is formed by the welded-sandwich method, the rolled product requires only a superficial cleaning to yield a useful material. Because of the reactive nature of titanium, the heating time must be minimized to prevent serious contamination of this metal. The milled-cavity plus cover-plate assembly method offers complete protection to the titanium, but the cover plate must be removed by milling or acid dipping after rolling. In welding, special care must always be exercised to prevent a Ti-steel fusion bond which is notably brittle and crack-susceptible. This is best accomplished by inert-gas-shielded arc welding of vanadium to steel and Ti to vanadium.

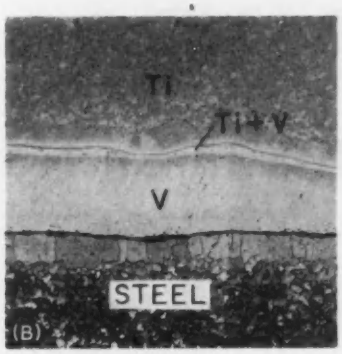
STRAIGHT TI-V-STEEL

The use of copper between the vanadium sheet and the steel base plate is optional; the value of its presence is discussed below. Using 1010-1020 steel as a base material, without copper in the compact, titanium-clad strips 60 in. long by 8 in. wide were rolled and tested. The following facts emerged:

1. Sound bonding occurs at rolling temperatures between 850 and 1000 C.

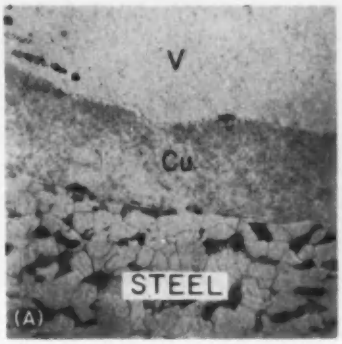
2. Reductions of 80% or more are required. This total amount of reduction can be accomplished in

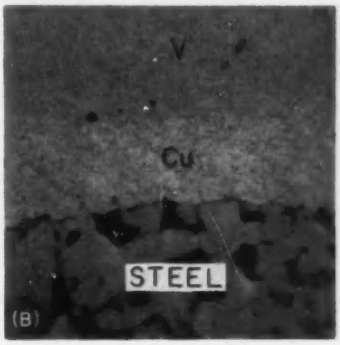




3 As-rolled . . .

titanium-vanadium-steel interfaces (A) after 88% reduction at 1000 C. Annealing 2 hrs at 800 C gives phase growth at steel-vanadium interface (B) and pearlite-free area in steel. Photomicrographs X100.





4 Interleaving . . .

vanadium and steel with copper eliminates interface phase, promoting a more ductile bond. Specimen at (A) was reduced 89% at 900 C. After 24 hr anneal at 800 C, interface compounds do not form (B). Photomicrographs X750.

either several large- or many small-reduction individual rolling passes; however, heating between passes is required.

3. The shear strength of such clads, based on a rather limited study, is in the vicinity of 19,000 psi.

4. Severe bends are possible with the as-prepared clad material (see first page) as well as with specimens subjected to anneals up 1000 hr at temperatures as high as 750 C. For example, a clad sheet prepared by the welded-sandwich technique can be bent 180° around a $\frac{1}{16}$-in.-radius pin. After 1000 hr at 750 C, another sample of the same material can be bent 180° around a $\frac{3}{16}$-in.-radius pin. In both cases the bond remains undamaged.

5. A phase appears at the vanadium-steel interface and is enhanced by annealing. Fig. 3 illustrates the presence of this phase, and its growth upon annealing at 800 C. Carbon has diffused to the vanadium boundary and a pearlite-free area is seen in the steel.

6. Presence of the interface phase makes the titanium easily strippable once a break has been formed.

COPPER HELPS

When a 0.007-in.-thick layer of copper is placed between the vanadium and steel, and the compact is rolled, several beneficial results occur:

1. Lower total reductions are necessary to promote good bonding; 70% total reduction seems to be the minimum value. Rolling temperatures are the same as without copper.

2. Bond ductility improves because no interface phase develops at any point. The bend ductility suffers only slightly upon annealing. A specimen which could be bent 180° over a $\frac{1}{16}$-in.-radius pin could still be bent 180° over a $\frac{1}{16}$-in.-radius pin after 1000 hr at 600 C. Fig. 4 illustrates the microstructural condition in such a material before and after annealing. The first-page photo shows the formability of this clad in the as-prepared condition.

3. When breaks are introduced by bending severely, the titanium cannot be stripped from the steel.

PROBLEMS REMAIN

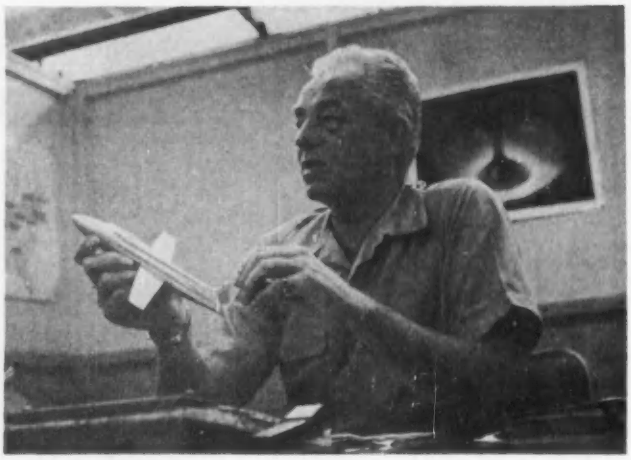
The feasibility of cladding titanium onto plain carbon steel has been demonstrated. Such clads combine the low cost and strength of steel and the corrosion resistance of titanium. The clad sheet is formable and is not seriously affected by prolonged anneals at elevated temperatures.

Two major problems remain before the material can be commercially exploited: (1) Special welding techniques must be developed so the material can be fabricated, and (2) the bonding technique must be adapted to commercial quantity production. Here, the current unavailability of vanadium in sheet form is an obstacle. However, with the present fast pace of vanadium technology, vanadium in sheet and other forms should be commercially available in the not-too-distant future.

Titanium can also be clad on stainless steel using procedures much the same as those employed for plain carbon-steel clads. The quality of such clads is not as good as the plain carbon-steel base counterpart, even when a pure copper layer is placed between the vanadium and the stainless steel. Although these clads leave something to be desired, they are sound and may be satisfactory for certain applications.

TECHNICAL NEWS

Air Force Sights In on Next Decade's Production Problems



WRIGHT - PATTERSON AIR FORCE BASE—"We have designs right now that we can't produce and materials we can't utilize effectively. What we need are the manufacturing processes to turn those materials and those designs into production parts." These facts were revealed by Col. John N. Dick, (right) Chief of the Manufacturing Methods Branch (MCPBM), Industrial Resources Division, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, during an interview with *Product Engineering*.

The need for developing a new technology has some ominous implications. Most important, it shows how we are losing advantage over the Communist world as the techniques we have become obsolete, while the U. S. and Russia start to develop new ones from scratch.

The Air Force, which as seen Russian aircraft improve at least as rapidly as our own, is therefore interested in pushing the development of new techniques. In the first years after the war, it promoted research on a somewhat restricted basis; more recently its search for new ways of production has been organized and coordinated in the shops and labs of American industry, in the universities, in the research centers of established foundations, and with trade associations such as the Aircraft Industries Association.

Why does the Air Force feel it must catalyze the know-how on which America prided herself, and which has always been one of her prime assets? The know-how is still here, and it is unsurpassed by that of any other country, but it's mostly geared to turn out yesterday's products faster and better. The needs of today already are met—by techniques which did not exist 10 years ago. Tomorrow will be served by a technology whose outline can be seen but dimly today.

Methods interesting the Air Force are primarily those that will produce airplanes, guided missiles, and perhaps space ships between 1960 and 1970. As a bonus, these methods might also produce cheaper and better gears, shafts and other parts for civilian products like machine tools, automobiles, sewing machines.

HOW THE SEARCH IS ORGANIZED

Main MCPBM function is to see that parts, components or assemblies become producible economically, and on time. To this end it sponsors programs aimed at developing non-proprietary techniques which it can then give wide dissemination in industry. Control over these developments is exercised by underwriting the necessary funds, avoiding duplication of effort, evaluating the worthiness of proposed projects, and following up the development of laboratory techniques into production methods.

Almost any new development in materials, fuels or engines gives birth to production problems. These are brought to the attention of the MCPBM, evaluated, and if deemed sufficiently serious, are themselves turned into projects. If industry can't solve the problem on its own and it falls within the Air Force's ground rules to sponsor the project, the procedure is as follows: 1. The problem is evaluated after which a work statement defines the phases of work and the objective; 2. The Air Force contracts with the low qualified bidders in industry, foundations or universities; 3. Such work is then guided technically and monitored by Production Process Specialists of the Air Force.

SEARCH COVERS MANY FIELDS

Not all projects are designed to meet the expected needs of industry five years from now. Some aim at improving quality, and lowering the cost of parts already in production. Projects span the range of manufacturing processes and methods.

Here's a glimpse at some of the projects and the reasoning behind them:

- Increased plane velocities (Mach 2 or better) will be accompanied by temperatures too high for the aluminum skins of today. Conversion to some stainless steel is indicated. But steel is heavy. Present sheet-manufacturing methods can come up with only a 10% tolerance in skin thickness. Needed is a way to produce sheet stainless of desired thickness, with a tolerance of only 2½%. Later this figure may be cut again.
- Production-type machinery is under way for a thin-gage stainless-

steel sandwich resistance-welded and with a corrugated type core—a sandwich composite ⅛ in. or more thick and 30 in. wide emerging in a continuous operation from coil stock.

• Foamed plastics have proved their worth as structural materials. But they fail at relatively low temperatures. Foamed metals will be a logical substitution, with aluminum especially desirable because of light weight. Development of a suitable process is pretty well along.

• Forging and extruding metals becomes easier when metal-to-die friction is lowered. The need: nonconventional die lubricants that are nontoxic, have suffcient viscosity, and will not contaminate die or part. Result would be increased tool life, increased press capcity, and lower part cost.

THE PROGRAM PAYS

Even when projects aim at finding processes that will not be in production until the next decade, results often have a way of getting immediate application. Projects completed in 1956 cost a little over $6 million and saved the Government better than $30 million. In addition, they brought about process mechanization, reduction of required plant and equipment, improvement of the product, miniaturization, and reliability.

YOUR PLACE IN THE PROGRAM

Any company can participate in the program and bid on any projects in its field once the company has satisfied the Air Force's technical and economic qualifications to carry out such development work. Here are just a few of the projects about to be allocated for further investigation: high frequency forging; precision forging of gears; beryllium forging; production of disks by radial extrusion; extruding metal by explosion; extrusion of wide, thin titanium panels; forming thick steel plate; grain size control in blades and buckets; casting of beryllium; ultra-high speed machining; electrical machining processes; glass flake reinforced plastics; resistance welded waffle-core sandwich; vee jewels; electric blanket brazing of sandwich structures; Teflon coating process for wires; high temperature non-metallic tool materials; and controlled heating equipment for piercing and forming of high strength metals just to mention a few.

Emergency Floats Boost Copter Cargo Capacity

NEW YORK—As a guard against unscheduled water landings, quickly inflatable (4-5 sec) donut-shaped floats are a functional design feature of this S-55 Sikorsky helicopter. CAA approved and weighing only 170 lb, the emergency pneumatic system will increase passenger and cargo load of copters currently requiring heavy pontoons for over-water operation.

Walter Kidde & Co. is the manufacturer. A pilot-operated solenoid valve sends compressed air from a 900-cu in. glass fiber sphere to 3-in. inflation units at each wheel, forcing free air into the rubberized nylon-fabric floats. Inflation is to 66 cu in. for the rear floats, and 58 cu in. for the forward floats. For climates with extreme temperature variations, the system has topping equalizers to bleed off or add air as needed.

Navy Announces Stretchout; Warns More to Come

WASHINGTON—The Navy has announced a $90 million stretchout in production on its aircraft and missile program as part of the over-all trimming of military budgets now taking place. Other cuts are expected to be made next year starting July 1. Navy said changes "are due to increasing costs, technological advances and budgetary limitations." Here is how major Navy programs now stand:

• F8U-1 Crusader, Chance Vought fighter—a small reduction in current procurement, and slowdown in planned production.

• F4D-1 Skyray, Douglas fighter—program remains the same, but a stretchout is scheduled.

• A3D Skywarior, Douglas attack bomber—modifications of the basic A3D are now in production with first flight tests slated for early next year. No changes announced.

• A4D-2 Skyhawk, Douglas attack bomber—program has been curtailed with accompanying slowdown and stretchout of deliveries.

• A4D-3 Douglas improved attack bomber—contract for four A4D-3's terminated.

• F9F8T Cougar, Grumman trainer—will be ordered in fulfillment requirements.

• F11F-1 Tiger, Grumman fighter—no change in procurement contracts.

• S2F-3 Tracker, Grumman carrier-

based anti-submarine plane–small initial production planned.

- T2V-1 Seastar, Lockheed trainer–procurement reduced earlier in the year; no further changes contemplated.
- F3H2 Demon, McDonnell fighter–minor stretchout in delivery schedule. No other changes.
- T2J-1 North American trainer–no changes.
- Regulus I and II surface-to-surface guided missiles–no changes.
- Sparrow I air-to-air guided missiles–current procurement unaffected; planned production near completion.
- Sparrow II air-to-air guided missiles (experimental)–production previously terminated.
- Sparrow III air-to-air guided missiles–currently going into production, no cutbacks planned.
- Sidewinder air-to-air missile–no changes.
- Tartar surface-to-air guided missile–no changes.
- W2V-1 Lockheed improved long-range early warning aircraft–program partially terminated.
- P6M-2 Seamaster, Martin patrol bomber–small downward revisions in P6M-2 procurement made in June. No further reductions contemplated.

"Dream" Control Data Center for Future Skyscrapers

MINNEAPOLIS–A miniature Supervisory DataCenter less than one-third the size of some of today's models and featuring new pushbutton techniques has been designed by Minneapolis-Honeywell Regulator Co. The Minneapolis-Honeywell system, though not now in production, may serve as a model for the control centers that will regulate heating, air conditioning and other functions in commercial and public skyscraper buildings of the future.

Highlight of the pilot-model "dream" control center is a translucent slide-projection screen no larger than a 21-in. TV screen. It enables the control engineer to read temperature at a glance. A few pushbuttons, instead of the 300 or more adjustment knobs necessary on similar equipment today, handle all control functions. The center has an 8-ft-long console control panel, compared with panels now in use that measure up to 30 ft.

In operation, two sets of 35-mm slides are furnished for each heating or air-conditioning zone in the building. One of the sets shows the floor plan and gives the location of thermostats controllable by the engineer. And a second set diagrams the fan system layout.

By projecting a slide on his screen, the engineer locks the control center automatically without affecting operations in other parts of the building. With a push button, he can learn instantly the area zone temperature. Another button raises or lowers the temperature automatically in the selected area.

It is also possible with such fingertip control to activate or shut off fans in the area, or perform other functions which will add comfort to the building.

Other control functions that can be panel-installed include wind-direction and velocity indicators, sun-intensity meters, electronic "people counters," supervision over the building's entire electrical and plumbing systems, centralization of fire and burglar alarms, automatic elevator controls and time programming systems.

They're Braced Against Loss of Defense Contracts

WASHINGTON–Recent Washington decisions to slash research contracts and stretch procurements have highlighted those firms with product lines made flexible to take the shock.

The pattern today shapes up about like this: Some companies with heavy defense commitments have long feared cuts in government spending and have been developing commercial lines to insulate themselves against it. Many big airframe manufacturers, with only a limited scope for developing commercial lines, have diversified into electronics and missiles to provide a broader base for government-contract competition. Many too, are pulling work formerly subcontracted back into their own shops to add ballast against contract cancellations.

Finally, there is a large nucleus of industrial firms that will continue to rely heavily on defense work. These companies–including both airframe manufacturers and aircraft suppliers–may have product diversification in the back of their minds, but for the present they are confident contracts cancelled now will be replaced by new ones soon.

There has been a growing trend among companies in a position to do so to look at the military portion of their product line in terms of what it does rather than what its original purpose was. This approach pushed Grand Central Rocket Corp. into the oil-well drilling field. Grand Central, a Redlands, Calif. company, is a subcontractor on the satellite and has developed considerable know-how in solid propellents. This know-how led it to team up with Borg-Warner to develop an oil-well fracturing tool. Their rocket propellent in combination with Borg-Warner equipment blasts away nonporous materials at the bottom of wells–freeing the passage of oil but with little surface disturbance.

There are no geographical or industrial boundaries to hedging against loss of defense contracts. One Midwestern research and development firm, anticipating cutbacks since the beginning of the year, has been concentrating on commercial business with the aim of cutting government work down to 30% of total volume. Also, it is seeking commercial rights to products and processes developed for the government. As a result, the company anticipates no loss of business volume or dislocation of research and development personnel.

Leese-Neville, a manufacturer of small motors in the Cleveland area, is another firm relatively unconcerned over the threat of a further slash in defense spending. As a hedge it has

been enlarging its commercial line. Part of its new program is a system for moving technical men and engineers around to "keep their fingers in both the government and commercial end of the business."

The big aircraft manufacturers are, in general, firmly tied to government contracts. Much of the technology they have developed will be of long-range value to civilian industry. But as one spokesman put it, "I doubt whether contractors could adapt much cancelled defense work to commercial aviation now. In some cases, there's the cost angle; in others, security aspects."

Hughes is typical of an aircraft company moving heavily into electronics and developing commercial lines. Commercial sales have risen from $400,000 in 1952 to over $20 million this year. Hughes has divisions working on VTOL, data link and guidance systems, and electronics. Among its most important and fastest moving products are quality semiconductors—those which by Hughes definition are significantly better than required for radio, TV, and industrial use. The company produces a memascope—electronic memory storage tube. For civilian use it produces a two-seat helicopter; for government, two versions of the Falcon—one radar-controlled, one infrared-guided.

Hughes expects to maintain a constant employment level. But it is entirely possible there will be localized disturbances as its far-flung divisions gain or lose contracts. This points up one aspect of the engineers employment dilema. Diversification offers an aircraft company some stability in its over-all operations and helps keep it financially sound. But when a contract is cancelled that effects a large part of a plant's work force, the displaced engineer may be several hundred miles away from another plant that is taking on personnel.

Douglas Aircraft has a $2 billion backlog—half commercial and one-quarter missile. Douglas' recently developed aircomb honeycomb is now going outside the aircraft industry into trucks, trailers, and building construction.

Boeing is optimistic on the outlook for defense work. It has been effected by cutbacks but expects new contracts to take up the slack. Talk is that cutbacks on the B-52J at Wichita were principally to get in shape to compete on projected contracts for chemical aircraft. Boeing is moving slowly into the missile field. The only industrial product it has done much with is a gas turbine. But this hasn't been pushed hard.

One Midwestern company, outside the core of the aircraft industry but with 90% of its business in aircraft accessories and components, is staking its bets on a continued high level of defense business. If the slide in government business continues, it would hurt, but the company is convinced cutbacks in manned aircraft will be compensated for in missiles. In either case its business will be good. It is supplying electrical systems for Boeing, Douglas and Fairchild, and has made a small move into the commercial aviation field. In the back of its mind is a hedge—acquisition of some firm outside the aircraft field.

The government's economy measures have had a considerably more severe impact on the West with its highly concentrated aircraft industry than on other regions where there is a broader mixture of defense and commercial work. The aircraft industry accounts for about 28% of total employment in Los Angeles area. Employment of small subcontractors —those in the 70-500 employee category—has dropped off 40%.

In Detroit, defense work constitutes only a small portion of the area employment. At General Motors, for instance, government contracts account for 5% of total volume. Ford has about $8.5 million in defense contracts. Its annual sales ran $4,647 million last year. Chrysler defense business has accounted for about 3% of its total sales this year.

ASTM To Set Up Specs of Radiation on Materials

PHILADELPHIA—Many of the 80 American Society of Testing Materials committees have plunged into the task of drawing up specifications for the materials that will be used in the development of nuclear energy, particularly nuclear reactors.

Here is a run-down of some of the major projects now under way.

In ferrous materials, specifications for tubular products now include a stainless steel with a limited tantalum content. This steel is used in reactor designs. Grades of stainless steel with especially low carbon content have also been standardized.

The problem of stress-corrosion cracking is under examination. Addition of a stainless steel tubular material to the ASTM classification A 268 is being considered. It will differ from type 430 steel in its carbon and nickel content.

The non-ferrous metals committee has set up a special subcommittee on light metals to establish its position in writing standards for light metals. In the meantime, work is underway to develop specifications for zirconium and lithium. Task groups are also collecting data on uranium, beryllium, tantalum, columbium, thorium and hafnium to be used in writing specifications as demand arises.

Committees dealing with manufactured masonry units and mortar masonry units are setting up a program to study contamination and decontamination of structural clay products and mortars exposed to radioactive materials. Ceramics hold promise as a material for joints and gaskets and are under investigation by the Committee.

Another committee is looking into unclassified information on aromatic hydrocarbons that may serve as heat-transfer materials.

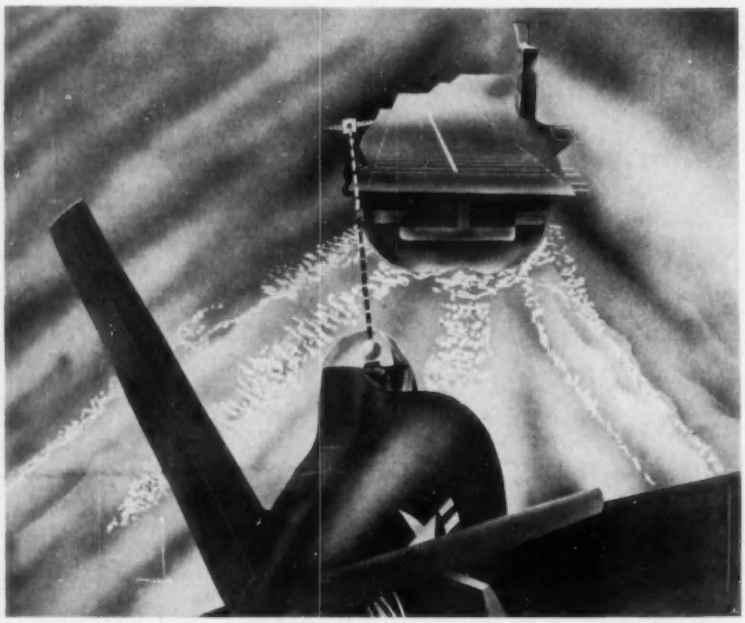
Task groups within the Committee on Industrial Water are preparing methods to determine gamma radiation from sodium 24 and potassium 42, and beta radiation from phosphorous 32, at concentration ranges from 1×10^{-8} to 1×10^{-4} microcuries per ml. This group will sponsor a symposium on Inspection of Industrial Water and Industrial Water Waste for Radioactivity at the annual meeting in Boston, June 1958.

Committees dealing with electrical insulating materials and plastics are

jointly sponsoring a subcommittee on radiation effects to establish standard methods for irradiation and methods for determining effects of irradiation on the physical and chemical properties of plastics and electrical insulation.

In the field of emission spectroscopy, a special subcommittee will cover methods of analyzing titanium, zirconium, and related alloys.

The widespread activity of ASTM committees in the nuclear field has been stimulated by creation of a special Administrative Committee on Nuclear Problems. This group, set up in January 1956, was charged with responsibility for (1) advising technical committees of the nuclear problems within their scope, (2) encouraging them to undertake research projects pertaining to nuclear energy problems, and (3) reviewing the status of committee work periodically.



"Meatball" of light, reflected on mirror at left of aircraft corner deck, gives Navy pilot 20 sec to perfect his approach. This guiding system replaces the old wigwag method that allowed pilot only four sec to perfect his landing.

Mirror Landing Device is Lifesaver for Pilot

PATUXENT RIVER, MD.—The Navy is installing on all aircraft carriers and many land stations a mirror landing system that promises to cut landing accidents by a third.

Engineered by Libby-Owens-Ford Glass Co., the system consists of a 4 x 4 ft curved mirror mounted on the port side of the ship, in an automatic stabilizing frame compensating for the roll of the carrier. Four source lights are beamed from an aft position to create a "meatball" effect which the mirror reflects to the pilot of an approaching aircraft.

If the pilot focuses on the optical glide beam provided by the reflected "meatball," the spot will be centered between the row of stationary green datum lights. If the plane is too high, the spot on the mirror will move up; if too low, the reflection will appear below the mirror midpoint.

A pilot has about 20 sec to perfect his approach from the time he first sights the mirror reflection until he lands on the carrier deck. However, when waved down under the old method, the pilot had only 3-4 sec.

The system, first developed by the British depends on extremely fine mirror surface tolerances.

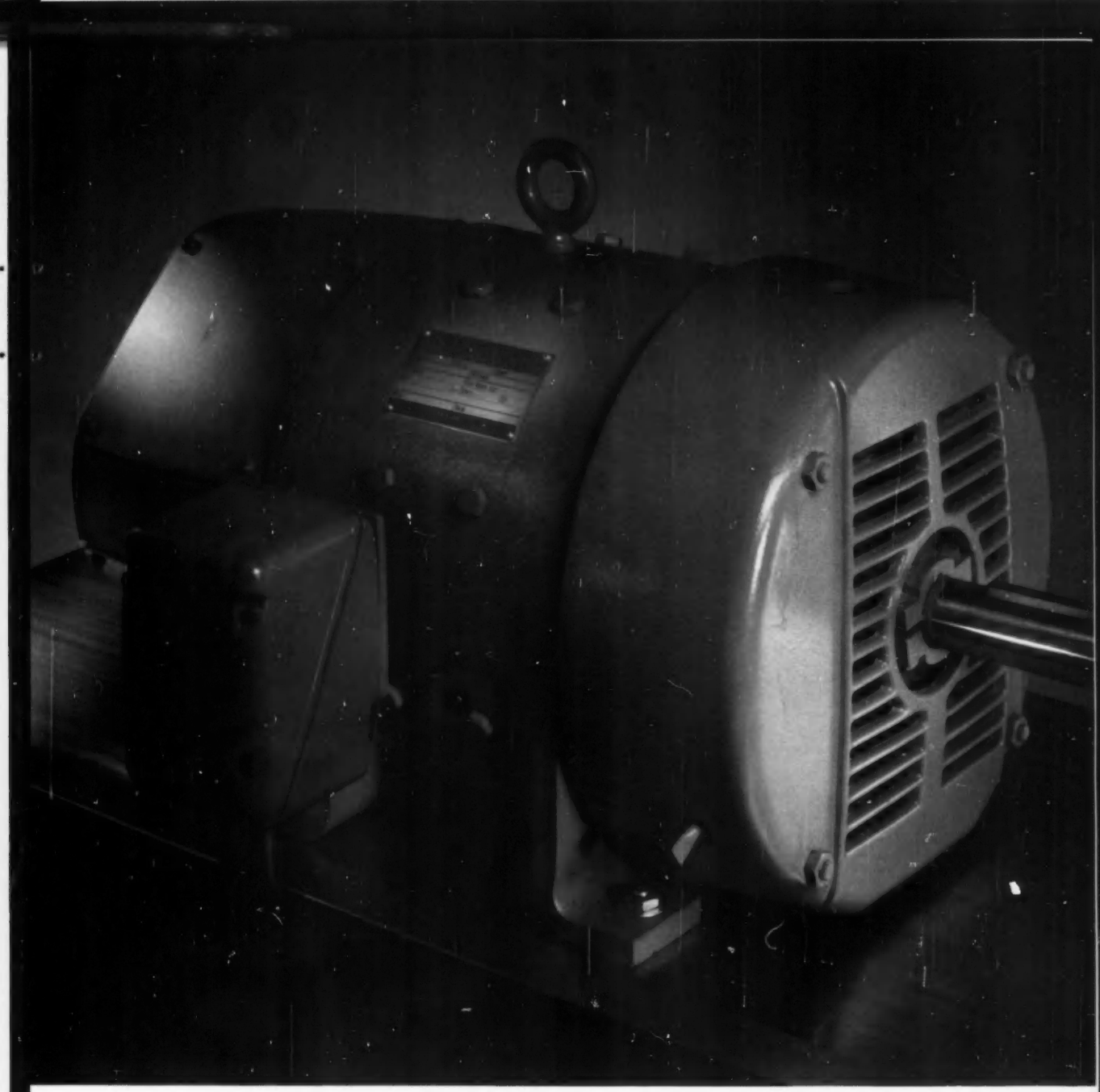
Superalloy Temperature Range Extended

METUCHEN, N. J.—Flame-sprayed boron nitride coatings for superalloys working at 2200-2500 F are still in the experimental stage at the Gulton Industries Ceramics Department, and provide a somewhat ironic example of the materials development cycle forced on aircraft designers over the last 15 years by increasing power-plant temperatures. Ceramic coatings extended stainless steels and other ferrous alloys to about 1900 F, only to be replaced by superalloys which can go to 1900 F plus, without coatings. Requirements now exceed 2500 F.

The basic coatings were originally developed by Dr. Paul Huppert, department director, as thermal barriers for 24-S and 75-S aluminum alloys, to extend their structural usefulness 200-300 F above the melting point. For superalloys, a special surface preparation permits standard flame-spray techniques for applying a coating with exceptional adherence under thermal shock and cold deformation.

Lithium compounds form the base of the new coatings: chromates, silicates, fluorides and recently, lithium silicofluorides. Boron nitride, the new ingredient, is extremely refractory, and the lithium compounds are added to lower the coating application temperature.

Noble metals, gold and palladium for example, add another potential to the new flame-spray technique. Dr. Huppert coats the boron nitride-lithium coating with a tightly adhering layer of one noble metal or the other, giving a highly reflective heat transfer surface. With reflectances over 90%, much of the heat that would weaken the coated part is thrown back. On the opposite side of the alloy, a highly emissive coating speeds away the heat that is absorbed.



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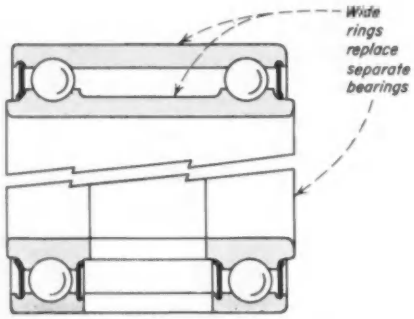
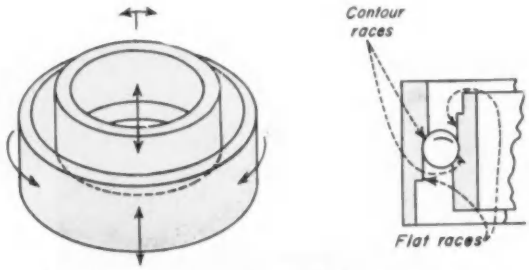
Simplify Design with Multi-function

Here are 14 examples of special ball bearings, each built to do more than one job.



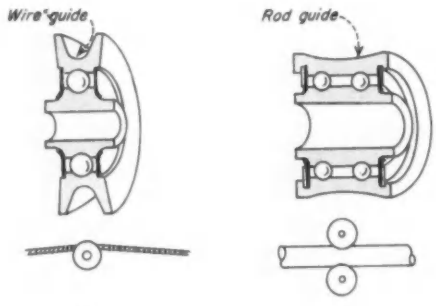
Wide inner and outer rings . . .

allow double-bearing design without expensive assembly. Separate bearings and spacer that would otherwise be necessary would also require special fastening to insure tightness between the bearings and spacer.



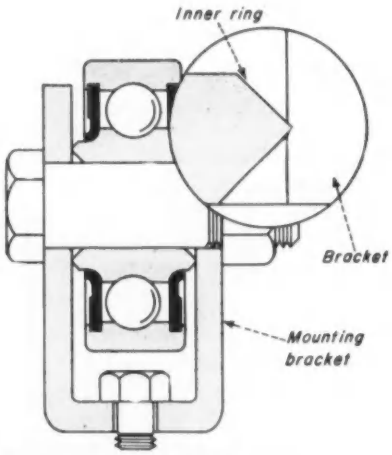
Combined contour and flat raceways . . .

permit universal motion of automatic milling-machine tracer spindle. Inner race moves in axial, rotational or alignment direction, allowing pattern to be followed exactly.



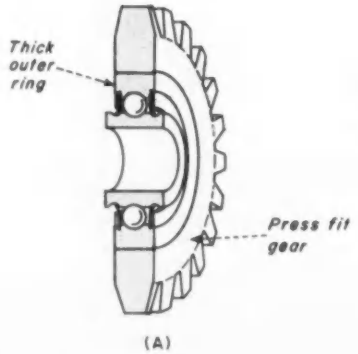
Deep-grooved outer ring . . .

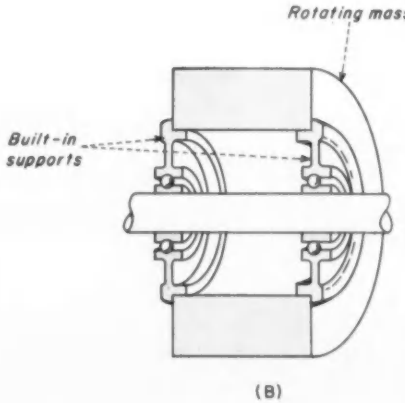
of single bearing (A) provides low-friction control-wire guide; shallow groove (B) guides push-pull rod without needing separate pulleys and bearings. For rod guide it is essential to mount bearings with sufficient clearance or adjustment to accommodate slight variations in rod diameter.



Sharp edges built into inner ring . . .

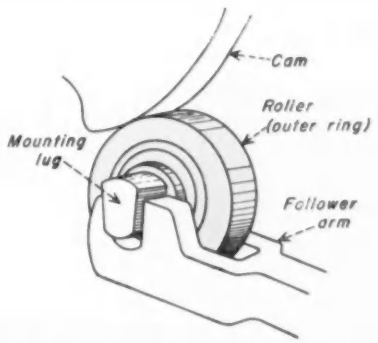
dig into bracket when bracket is tightened. This design is useful when radial movement of mounted bearing must be minimum, as in low-friction control systems with push-pull or wire linkages.



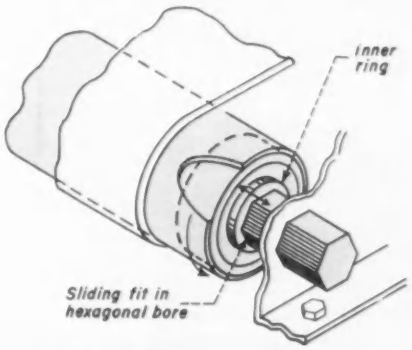


Ball Bearings

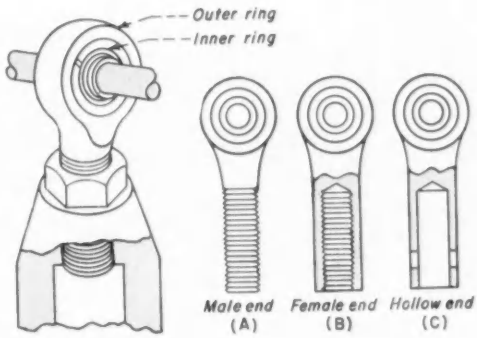
HOWELL L. POTTER *Chief Engineer, Fafnir Bearing Co.*



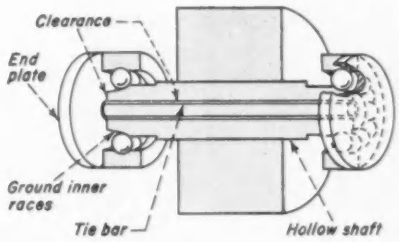
Mounting lug integral with inner ring . . .
provides quick mounting for cam follower. Outer ring is specially designed to act as roller.



Hexagon-shaped bore in inner ring . . .
permits lateral movement or expansion of roller during rotation, so bearing can operate in widely varying temperatures such as in conveyor-belt systems for hot materials.

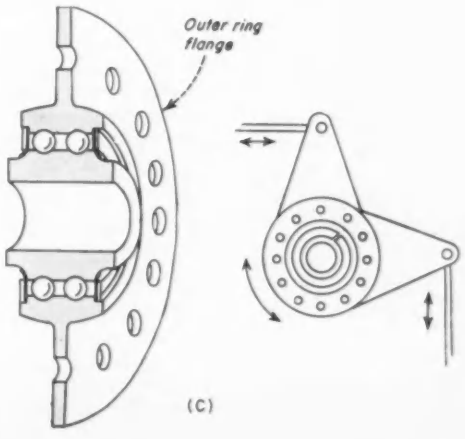


Rod-end bearings . . .
are available with male (A) or female (B) threaded, and hollow (C) shanks. Shank, integral with bearing, can be easily mounted on rods for push-pull linkages.



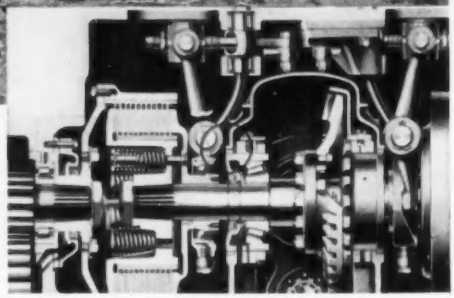
Hollow shaft . . .
here is inner ring of bearing. Tie bar through the shaft and the adjustable end plates hold bearing to correct fit. Tie bar and shaft are of similar material. This maintains fit in varying ambient temperature.

Dual-function outer races . . .
usually reduce assembly costs and number of parts required and increase mounting accuracy. Thickened outer ring (A) lets gear be press-fitted without damage to bearing. Supports built into bearing (B) provide mounts for rotating mass. Outer ring flange (C) permits bell cranks to be mounted in variety of positions.



Dust Flies Fast and Furious

...when the TRAXCAVATORS* go into action!



CUTAWAY of a Caterpillar No. 955 Traxcavator to show one of the spots protected by seals of American Felt.

But vital innards are kept grit-free and oil-tight with seals of AMERICAN FELT

The Traxcavator, made by Caterpillar Tractor Co., is called on to handle some mighty tough jobs. Logging, grading, loading gravel and dirt are just a few. Under these conditions even the best-made engines and machines need their vitals protected against grit, dust, water and mud, and at the same time have the oils and greases kept grit-free and sealed in. To do this dual job of keeping out dust and grit and keeping in oil and grease, Caterpillar Tractor Co., Peoria, Illinois uses seals of American Felt . . . in their D4 Tractor, No. 955 Traxcavator shown and other pieces of equipment . . . to insure reliable performance and long life.

American makes various types of felt for sealing purposes, and supplies it as desired, including the very important laminated synthetic rubber and felt OILFOIL seal, cut to size. For information, write for Data Sheet No. 11, "Felt Seals, Their Design and Application."

Caterpillar, Cat and Traxcavator are Registered Trademarks of Caterpillar Tractor Co.

American Felt Company

GENERAL OFFICES: 78 GLENVILLE ROAD, GLENVILLE, CONN.

SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, Boynton Beach, Fla., San Francisco, Los Angeles, Portland, Seattle, San Diego, Montreal. — PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I. — ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.

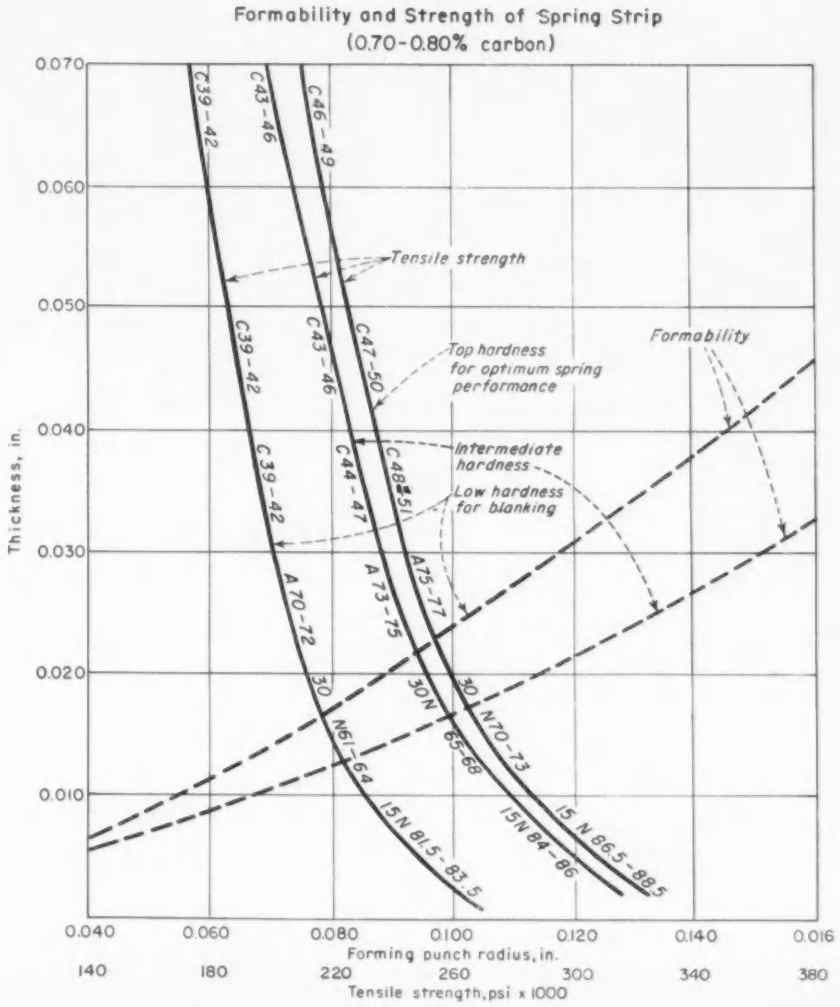
Formability of Flat Spring Material

JOHN B. BECKWITH, *Product Engineer, The Wallace Barnes Company Div., Associated Spring Corp.*

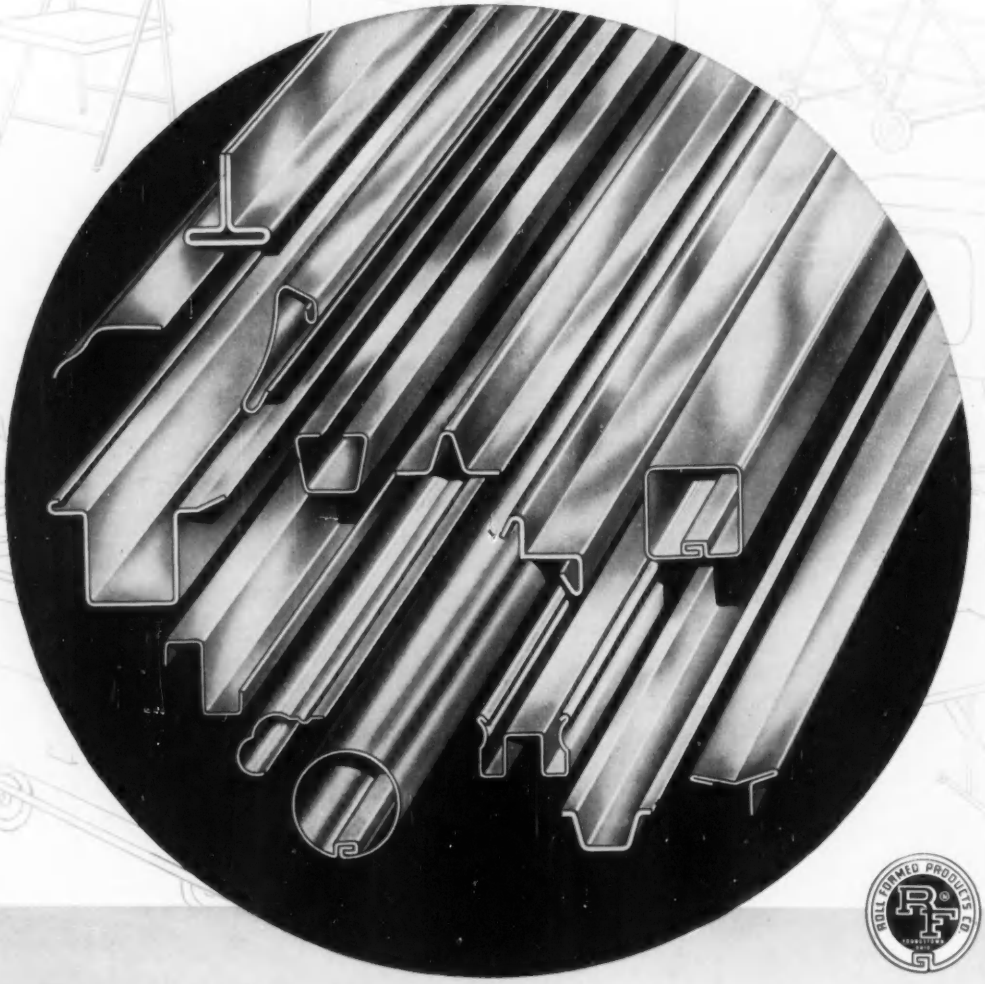
THE choice between annealed and pretempered spring steel is generally determined by the severity of required bends or degree of distortion that might occur in hardening the annealed material. As a rule of thumb, length-to-thickness ratio should not exceed 100:1 to prevent distortion.

Sharp bends can only be made with annealed material. With 0.70% to 0.80% carbon, annealed material will bend flat on itself across the grain up to 0.072 in. thick. With the grain, maximum thickness for such bends is only 0.30 in. Above these sizes bend radius must equal stock thickness to avoid fracture when bending with the grain.

Pretempered material does not distort during hardening but poor formability limits its use. Formability depends on carbon and alloy content, hardness and working stress. Minimum forming radius on the punch can be found from the formability curves in the following two charts. Values of tensile strength for given hardnesses are also plotted.



(Continued on page 127)



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We deliver them to your plant already punched, notched, pierced and cut to length. Our modern plant equipment performs all these operations continuously, cutting your material cost. These ready-to-use parts speed your production and eliminate unnecessary handling.

Whether it be carbon, galvanized or stainless steel, copper, aluminum, zinc or clad metals, send us your blueprints and let us help you to produce a better product at lower cost. Write for Catalog 1555 to get an illustrated story of the Roll Formed process.

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COMPANY

MAIN OFFICE AND PLANT
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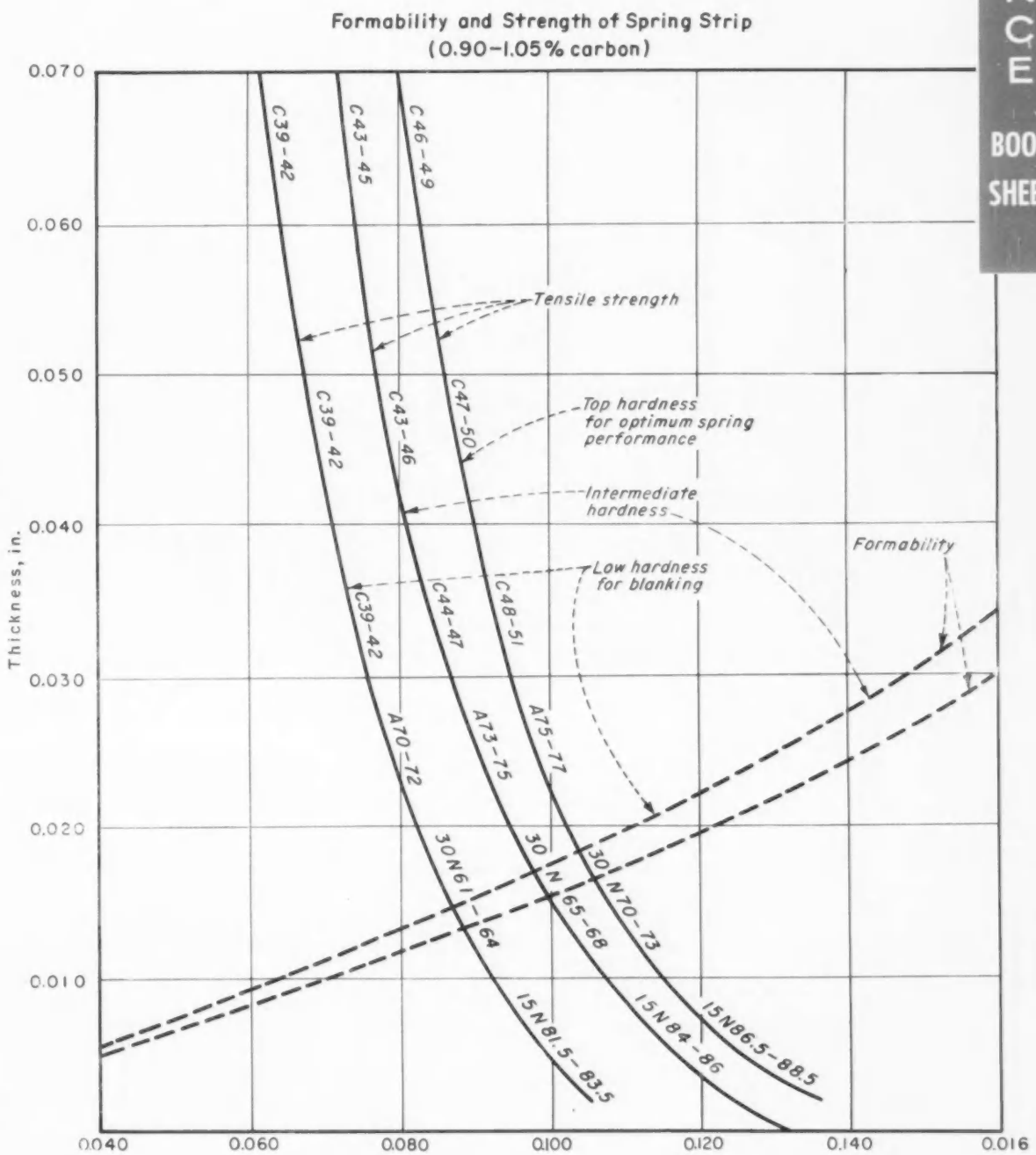
Formability of Flat Spring Material (continued)



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added heat resistance
at no added cost
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These compounds are so heat resistant that molded products show no distortion after repeated immersion in boiling water.

1. CYMAC 400 Polymethylstyrene—offers unusual heat resistance plus all the desirable properties of polystyrene: excellent electrical properties, clarity, luster, and unlimited range of transparent and opaque colors.

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Both of these new molding compounds provide the added value of remarkable heat resistance at costs no greater than competitive materials.

These new methylstyrene thermoplastics will help you upgrade existing molded products and find new consumer and industrial applications.

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NEW COMPONENTS and MATERIALS

SPECIFIED BY PRODUCT ENGINEERS

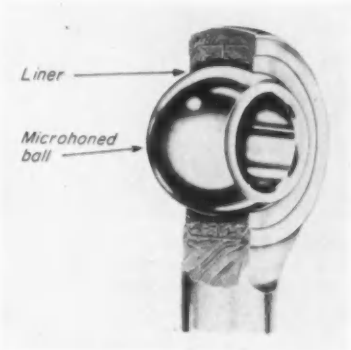
Self-lubricated Bearing with Teflon-glass Liner Takes Loads to 60,000 psi

This bearing is a composite structure consisting of two fused layers. The bearing face is a weave of Teflon fibers interwoven on the back with glass fibers. The back-up layer is a weave of glass fibers impregnated with thermosetting phenolic. The layers are bonded and cured at elevated pressures and temperatures, giving a dense lattice of Teflon fibers facing the bearing surface and intimately supported by the glass-phenolic structure.

Under load, when intimate contact exists between the two bearing surfaces, the separate strands of Teflon are locked and prevented from extruding. Bearings with these liners are said to be capable of supporting static loads up to 60,000 psi.

One successful application has been the self-aligning bearing or rod end. The ball is usually made of corrosion-resistant steel, and hardened. Its surface is finished to unusually close tolerances by microhoning, held to 3 micro-inches.

The liner is pre-formed by a drawing operation and bonded to the inside of the retainer. The two retainers are then assembled around the ball and pressed into the outer ring of the bearing or the body of the rod end. A lip is subsequently spun on the outside of each retainer and the entire assembly is cured at elevated temperature and pressure.



In spherical bearing, Teflon-glass fiber liner is bonded to inside of retainer.

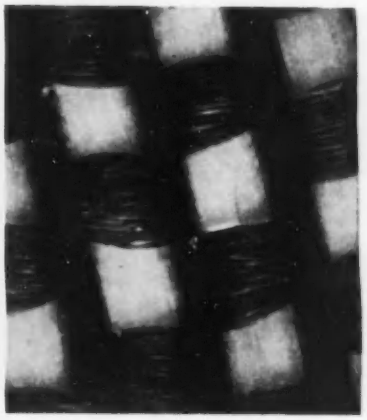
Under load, the Teflon face coats the outside of the ball so that in actual service the relative movement is between two Teflon surfaces.

Even though the Teflon coating on the ball is extremely thin, tests of the coefficient of friction indicate that lubrication is extremely good, showing friction coefficient values, within certain range of surface speed and unit pressure, as low as 0.01 and in no case, throughout the range of temperatures from −65 F to 400 F, does this coefficient exceed 0.04.

Up to 10 times the life of metal-to-metal lubricated bearings, even with the best periodic lubrication, has been reported. Bearings of comparable size can be subjected to dynamic loads considerably higher than those possible with metal-to-metal bearings. Available only on order, with reasonably good delivery schedules. Micromatic Hone Corp., 2205 Lee St., Evanston, Ill.

For more information—
Circle 1, inside back cover

Bearing face is composed of interwoven Teflon fibers.



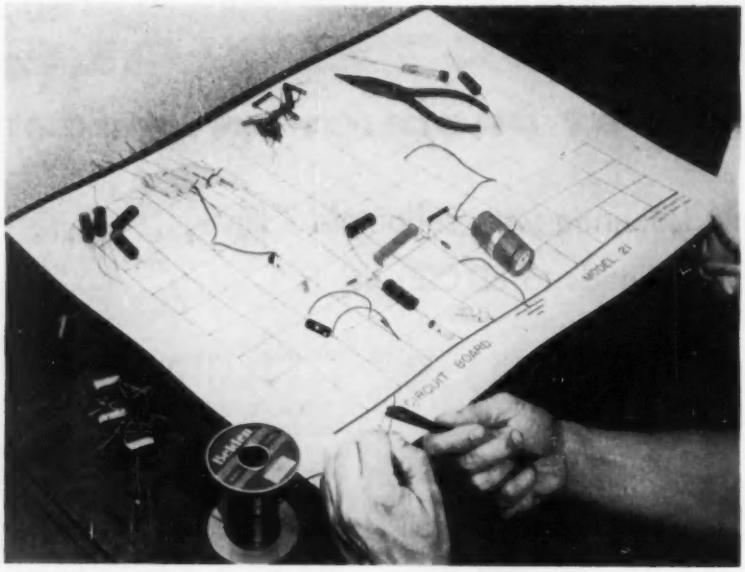
Glass fibers woven into back of liner support Teflon and prevent extrusion.

Conductive Cells Simplify Circuit Development

Circuit component leads, or the ends of jumper wires, are electrically connected by inserting them into conductive cells or "pockets." Result is a low-resistance contact. Individual components can be replaced or reassembled without damaging leads or loosening contacts, because the only connection between components is the electrical contact through the conductive material.

One application is a circuit board made up of 130 conductive cells, into each of which four or more component leads can be inserted. The board surface is covered with a white elastic material imprinted with a grid pattern. Grid lines serve to locate the individual conductive cells, but do not enter into the circuitry. The only exception is the line of 13 cells across the base of the grid, internally connected to form a common ground.

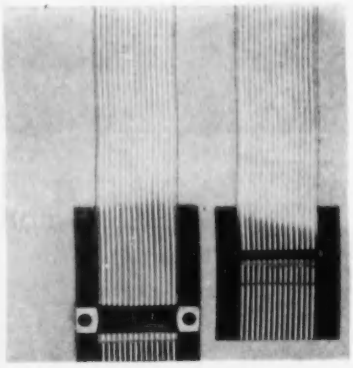
CONTINUED ON PAGE 130



The elastic covering is cut at each grid intersection point to allow easier insertion of component leads into the conductive pocket below. This arrangement prevents loss of conductive material, also provides a method of gripping the individual wires to hold circuitry in place during assembly and actual use.

Grid lines help organize the breadboard circuit into the two-dimensional pattern used in printed-circuit design. In addition, the white surface of the board may be marked by a grease pencil to show the electrical values of components. Boards measuring 17 to 22 in. now in production. Other sizes are scheduled. Price is $12.50. Van-Dee Products, 300 Ocean Ave., Laguna Beach, Calif.

For more information—
Circle 2, inside back cover



conductors for ordinary cable having No. 22 wire insulated with 0.10 in. wall. A 100-ft roll of 50-conductor cable weighs 2½ lb.

Interconductor capacitance is less than 5 mmf per ft between conductors. Each conductor has a conservative rating in free air of 1 amp—adequate for most signal circuit requirements. It is interesting to note that a rating of 300 v is achieved with a maximum cable thickness of only 0.011 in. The cable has been successful in applications requiring continuous flexing on a radius of ¼ in.

Tape is available from stock; price about 80¢ per linear ft for 14-conductor tape. Tape Cable Corp., 790 Linden Ave., Rochester 10, N. Y.

For more information—
Circle 4, inside back cover

Air Motor for High-temperature Operation

A pneumatic power unit that provides a power source for such applications as thrust reversers, accessory drives, actuation of air inlet and nozzle-positioning systems, and reactor-rod positioning has an exceptionally high torque-to-inertia ratio. The units will follow electronic modulation, delivering virtually instantaneous starts and stops. One model reportedly accelerates from zero to 100 rpm in 0.0004 sec, operating under 30 psig of applied air pressure against an opposing force of 20 in.-lb. Units are instantaneously reversible.

The air motor is controlled by an external signal which drives a fully balanced, center-fed, four-way pneumatic barrel valve. Valve rotation pressurizes the motor for either clockwise or counter-clockwise rotation.

Materials are high-temperature magnesium alloys, stainless steels and stellites, matched to eliminate problems of differential expansion. Motor gears are radially mounted and axially positioned by pivot balls. Ball-mounting of the valve barrel and control shaft reduces friction and increases positioning accuracy.

Units are available in ratings from 0.66 to 30 hp, operating on pressures from 10 to 300 psig. Built to order only; priced according to individual specifications. Lear, Inc., 110 Ionia Ave., NW., Grand Rapids 2, Mich.

For more information—
Circle 3, inside back cover

Electrical Conductor Tape

The cable is a ribbonlike, flexible film in which are imbedded flat copper conductors, .0015 in. thick and surrounded by transparent polyester insulation. Conductors have 0.100 in. center-to-center spacing in accordance with the recommended RETMA grid pattern for printed wiring. Nine standard sizes have been established, having 9, 14, 17, 21, 27, 30, 36, 40 or 50 conductors.

Conductor density is 1160 per cross-section sq in. compared with only 225

Remote Positioning Without Feedback Reference

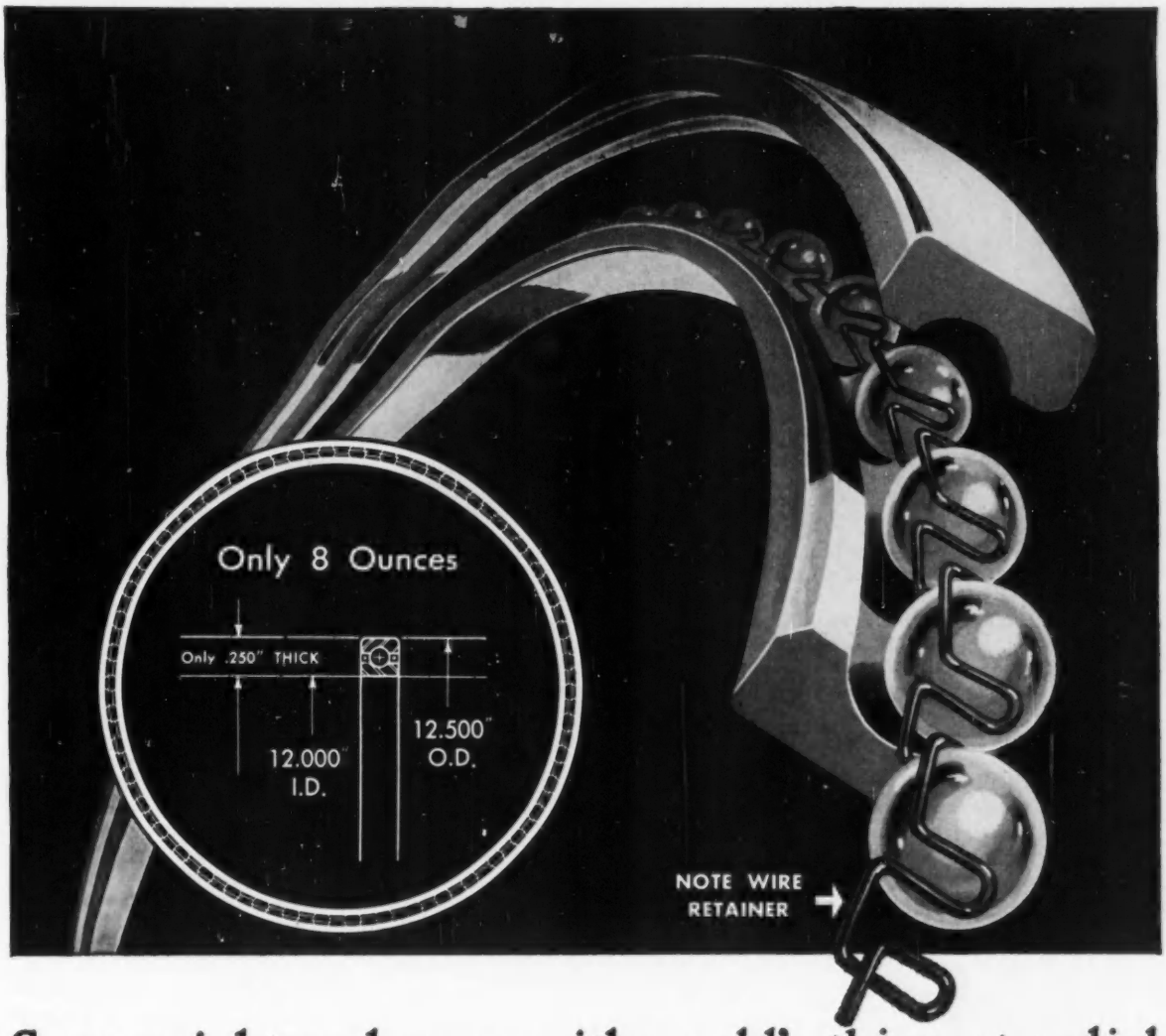
Remote power positioning without feedback reference is possible with two lines of motors: one a step type that indexes in 60°, 30°, 15° or smaller steps; the other an induction motor that provides continuously adjustable power positioning.

The step motor is based on the principle that when a squirrel-cage rotor having a special grouping of bars is placed in a single-phase field, the rotor will position itself in relation to this magnetic field.

Rotor indexing is obtained by energizing the stator windings in the desired sequence. Three control wires will provide six or more steps per revolution; continuous connections to the leads will provide continuous stepping.

Continuously adjustable power positioning is obtained by operating an induction motor from an a-c variable-voltage power supply so that positioning in any portion of a revolution is in relation to a voltage ratio. Variable voltage transformers, saturable reactors and similar devices can be

CONTINUED ON PAGE 132



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

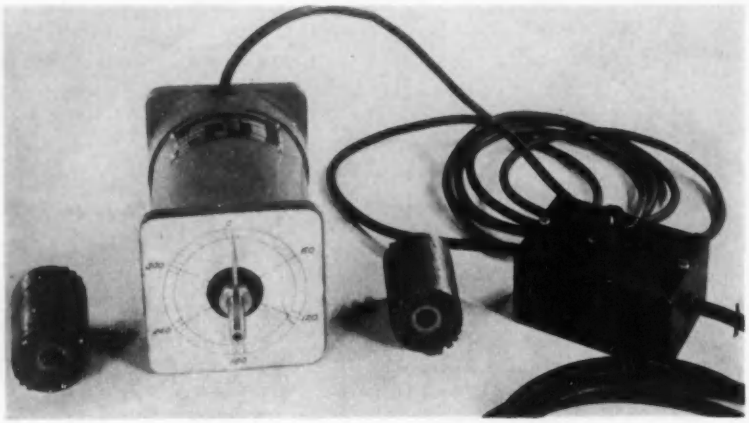
Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561

All types of ball and roller bearings — 4" to 120" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings.



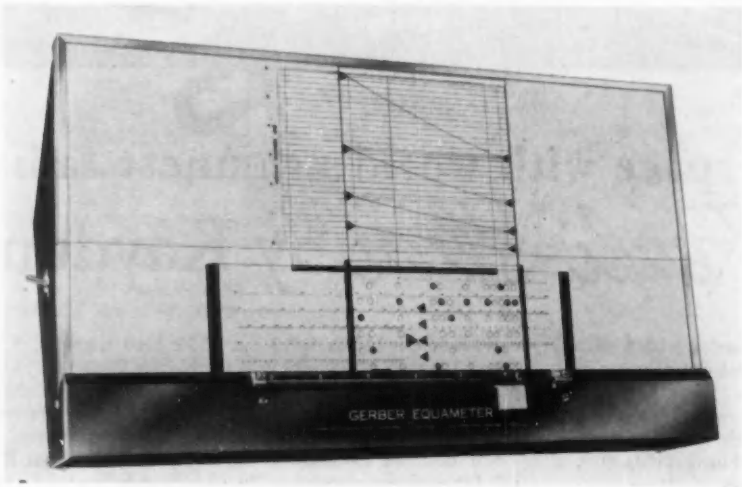
used to energize these positioning motors.

They can be directly coupled, without damage, to rotating shafts operating at high speeds. Therefore, where the application requires, motors can be operated at slow speed and, without de-clutching, driven at high speeds. They will stop and hold at a fixed point in a revolution, and two or more units can be accurately synchronized.

They can also be operated as polyphase induction motors in the conventional manner. Torque ratings are equivalent to torque developed by standard motors in the same frames. Capacities available are limited only by the characteristics of the required single-phase supply.

Delivery is about six to eight wk after approval of sample motors, at prices comparable to this manufacturer's torque motors. B. A. Wesche Electric Co., Cincinnati 42, Ohio.

For more information—
Circle 5, inside back cover



Manual Computer Fits Curves or Develops Equations

This device performs harmonic analyses and curve fittings on plotted or recorded curves, and can analyze a curve in terms of Fourier series, power series, or orthogonal polynomials (least square fits). It will also produce the derivative or integral equations of a given curve.

The manufacturer states that any such equations can be obtained quickly and easily by an engineering aide with little or no mathematical background. The device will convert raw data to a form acceptable to large digital or analog computers, eliminating expensive analog-to-digital converters. Polynomial equations can be fitted to curves or test points. A 12-term Fourier analysis can be obtained in about 7 min.

The instrument's working surface is illuminated from below for easy operation, and designed to read a specimen with a maximum vertical amplitude of 5.9 in. for cycle span of 9 in. or less. Gerber Scientific Instrument Co., 162 State St., Hartford 3, Conn.

For more information—
Circle 6, inside back cover

Dual-Speed Hydraulic Cylinder

This hydraulic cylinder provides alternating speed and power cycles in the same basic unit, employing a single pump and motor. It is said to be possible to substitute this unit directly for single-cycle cylinders with a minimum of modification and at savings to 70% in over-all cycle time. The cylinder is equipped with automatic valving; the shift from low-power high-speed to high-power slow-speed stroke being effected by spring-loaded valves in the head. They respond to increases and decreases in system pressure.

Applications are expected to include such construction machinery as bucket loaders; hydraulic presses and other equipment where fast opening and closing strokes alternate with full power work stroke; ship steering where speed and power demands vary with weather and sea conditions; opening and closing of dam gates; any equipment where working components are moved or positioned during nonworking strokes and where increased speed of such movements results in a reduction of over-all cycle time.

Basically, the cylinder is a three-chambered design. Two primary high-speed chambers, opposing one another, are located around a third, power cylinder. Normally the cylinder operates on the outer, high-speed chamber. When load increases to the point that the power of the outside chamber is insufficient, the inner chamber automatically becomes operative to provide maximum power at slower speed. When load drops, the outer chamber again takes over, bypassing to the power chamber in such manner that it is full at all times and ready, without any time lag, to deliver additional power as demanded by the work. The opposing outside chamber provides high-speed retraction of the cylinder. Delivery is about 90 days; prices comparable with standard cylinders. Crown Eng. Corp., 4700 Washington Ave., Houston 8, Tex.

For more information—
Circle 7, inside back cover

CONTINUED ON PAGE 134

halos...

for harassed engineers*

Are your leather oil seals or packings giving you headaches instead of halos? Your best cure for this situation — specify IPC.

Why?

Well, because IPC specializes in the custom approach to packings problems . . . leather or synthetic. Better materials and manufacturing techniques add up to better results.

You might be amazed at the applications which are solved by IPC leather packings — plain or impregnated. Ask your IPC representative for a complete rundown . . . *today*.

**Production and maintenance folks, too!*

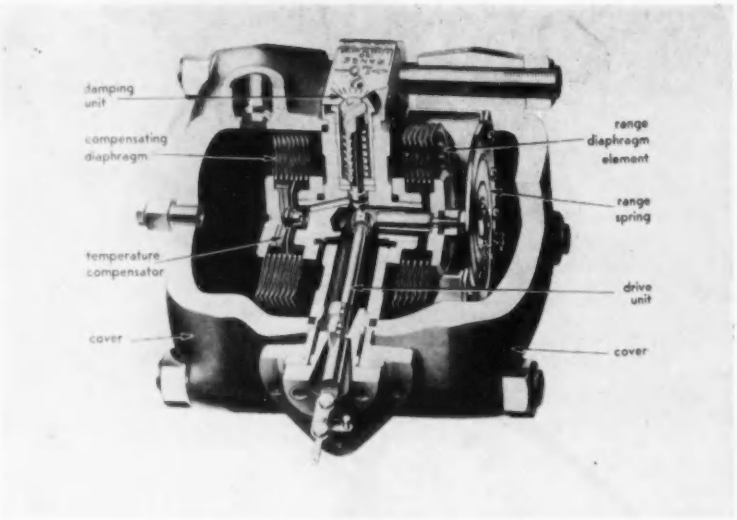
Packings
Oil Seals
Precision Molding

IPC

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

P5



Meter With Over-range Protection

Each pair of diaphragm elements is welded at their outer circumferences and to opposing faces of a series of spacing rings at inner circumferences. Over-range pressure on either element forces filling fluid through a connecting passage, around an adjustable damping plug and into the opposite element. The unit under pressure compresses so that the spacing rings form a metal-to-metal column and each pair of diaphragms is nested, preventing over-range damage. A bimetallic compensator inside the high-pressure element varies the fluid capacity of the element according to temperature changes.

The low-pressure element, working against a thermally stable range spring, is connected to a bellows-sealed drive arm, which is operated through a metal flexure member to drive the indicating or recording mechanism.

Differential ranges are 0-20, 0-50, 0-100 and 0-200 in. of water. Meter is available in rectangular or circular case, yoke or flush mounted, for 2000 psi maximum pressure. Diaphragms are Type 316 stainless steel; body is forged steel, cadmium-plated or Type 316 stainless; range spring is Ni-Span C metal; and end caps are forged steel, cadmium-plated or forged Type 316. Pressure connections are tapped for $\frac{1}{4}$ or $\frac{1}{2}$ in. NPT. Prices range from $300 to $400, depending on steel or stainless-steel construction. Delivery is scheduled for about 14 wk. Foxboro Co., Foxboro, Mass.

For more information—
Circle 8, inside back cover

Pneumatic pressure reducer . . .

with $\frac{1}{4}$-in. ports weighs from 0.17 to 0.25 lb, depending on spring Size is $\frac{7}{8}$ x $3\frac{3}{4}$ in. May be supplied with or without built-in relief valve. Adaptable to hydraulic application. Produces straight line regulation, with leak-tight shut-off rated capacity in excess of 0.1, initial pressure drop under flow conditions of from 10 to 50 psi, depending on pressure and spring. Normal temperature range is from —65 F to 225 F for pneumatics, with higher temperatures possible with modification of the internal design. Pneu-Hydro Valve Corp., 364 Clenwood Ave., E. Orange, N. J.

For more information—
Circle 9, inside back cover

Solenoid-operated step switch . . .

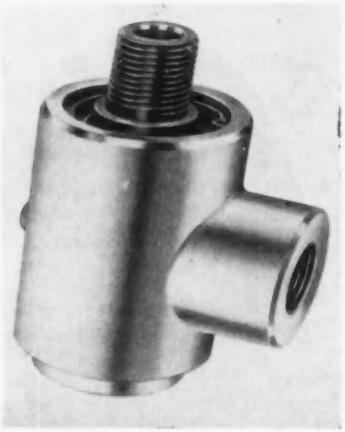
controls 24 separate circuits and is designed for motors, motor controllers, solenoid-actuated devices and systems. Switching capacity permits carrying loads normally handled by relays. Contacts make and break simultaneously. Programmer is unaffected by vibration of 50-600 cps at 0.05 double amplitude and 15-G impact shock. Unit can be motor driven without hunting. Size is 3 x 9 in.; weight, 4 lb, 2 oz. Built to specifications for delivery in about 60 days. Cost is $850. Mason Electric Corp., 3839 Verdugo Rd., Los Angeles, Calif.

For more information—
Circle 10, inside back cover

Three-way lock washer . . .

has barbs on both ID and OD. Barbs are placed to meet the particular application, hardened to permit embedding in the mated metal. Locking is said to be vertical, horizontal and rotary. Hi-Standard Stamping & Mfg. Co., 18228 Couzens, Detroit 35, Mich.

For more information—
Circle 11, inside back cover



Rotating union . . .

for the introduction of air or hydraulic oil under pressure into clutches of power shovels, cranes, drag lines, drilling rigs, logging equipment. Uses hexagonal socket in the end of the rotor to shorten overhang and facilitate installation in tight quarters. Sealing is accomplished by two micro-lapped end face sealing elements. For hydraulic service, the seals are 52100 oil-hardening steel running against alloy bronze. For air, a carbon graphite seal is used. O-rings seals are used. Operating specifications are 1500 rpm, 2000 psi for

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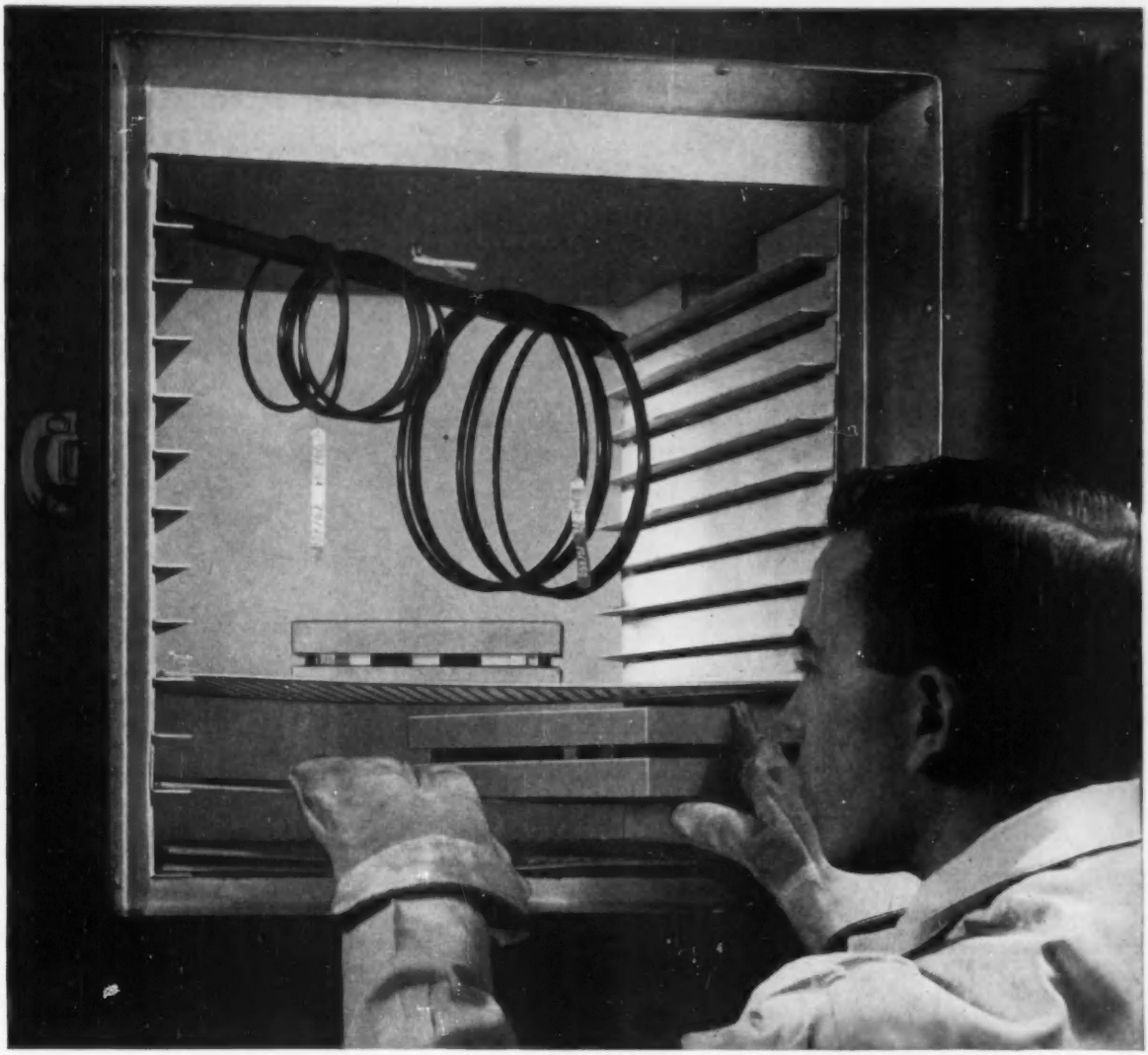


PRECISION "O" RINGS

Quality proved by all ASTM Tests

Precision "O" Rings made from Compound 830-70 meet or exceed all the SAE 120-R requirements for heat, oil resistance and other properties.

100% better compression set. Remarkable superiority in 300° F hot oil. 100% better Fatigue Test life.

For manufacturers of automobile, machine tool, farm equipment and similar equipment, Precision Compound 830-70 is your answer to positive long sealing life.

Have a sealing problem? You'll find the answer at Precision! There's a Precision engineer ready to help you.

Get your free copy of our engineering data sheet on Compound 830-70.

Specify Precision—first in Quality

Precision Rubber Products Corporation

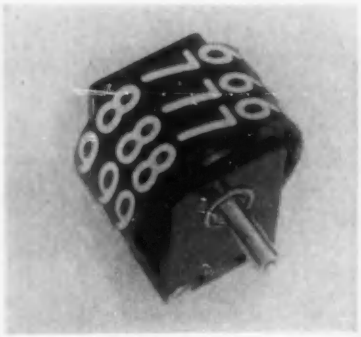
"O" Ring and Dyna-seal Specialists

Dept. 3, Oakridge Drive, Dayton 7, Ohio

Canadian plant at: Ste. Thèrése de Blainville, Québec

hydraulic service; 150 psi for air service. Housing is forged aluminum alloy, the coil spring is stainless steel, and the outrigger bearing is self-lubricating bronze. Available with rotors having $\frac{3}{8}$ or $\frac{1}{2}$-in. right-hand pipe threads as well as $\frac{5}{8}$-in. 18 NF threads. Deublin Co., 1155 Waukegan Rd., Glenview, Ill.

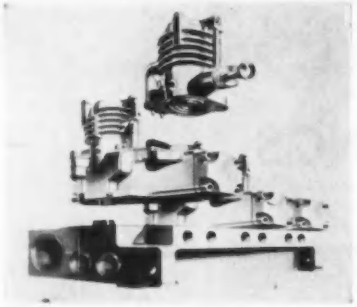
For more information—
Circle 12, inside back cover



Internal pinion decimal counters . . .

capable of operating at speeds above 500 rpm, are available in two, three and four digit versions at present. Numerals are $\frac{1}{4}$-in. high. Bowmar Instrument Corp., Plant 2, Fort Wayne, Ind.

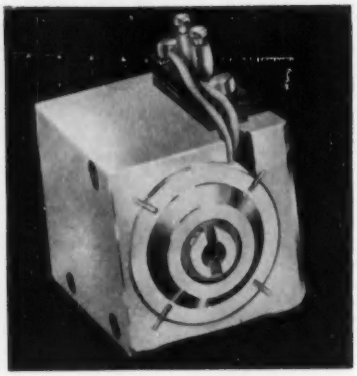
For more information—
Circle 13, inside back cover



Plug-in, four-way control valves . . .

fitted with built-in plugs and connectors are said to complete electrical connections automatically. Available in single and double solenoid types, for manifold or sub-base mounting. Designed for control of smaller devices, the $\frac{1}{4}$-in. valves are for 30-250 psi air service with solenoid coils for a-c or d-c, any voltage. Cylinder ports and inlet are tapped $\frac{1}{4}$-in. NPT. Solenoid pilots, built to JIC standards, are interchangeable between single and double solenoid types. With aluminum bodies, manifolds or sub-bases, end caps, spacers and pistons; hard chrome-plated stainless steel stems; Fabrecka-backed stainless steel shock pads and standard O-ring packers. Service life is reputed to exceed 25 million cycles. Valves are said to afford fast operating response. Available for shipment from stock. Valvair Corp., 454 Morgan Ave., Akron, Ohio.

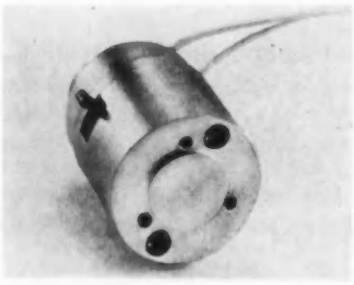
For more information—
Circle 14, inside back cover



Tiny, linear-stroke solenoid . . .

for instrumentation and control is shock-resistant and meets Air Force environmental requirements for installation in fighter planes. Weighing less than 1 oz, the solenoid is made of cold-rolled steel finished in cadmium plate. Rated at 28 v, the plunger stroke bridges a gap of 0.080 in. at 24 v and exerts a pull of 6 oz, min. Dimensions are 0.672 x 0.622 x 0.622 in. J. A. Maurer, Inc., 37-01 31st St., Long Island City, N. Y.

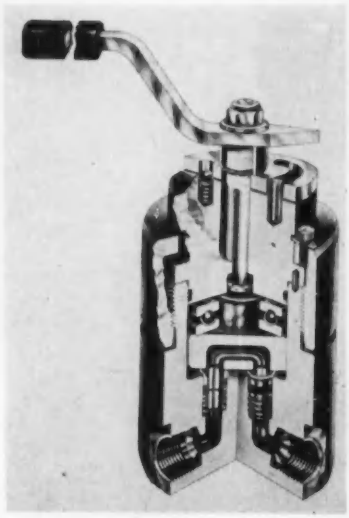
For more information—
Circle 15, inside back cover



Mechanical, high-speed clutches and brakes . . .

for application in automatic control, computing machinery, servo systems, or applications where relatively small forces are available to control torque transmission. Amplification ratio is 200x. Entire clutch mechanism with built-in clutch controls and bearings is housed in an envelope, 1 in. dia max and $1\frac{5}{8}$ in. long. Typical ratings are 10-lb torque min at shaft speeds tested to 6300 rpm with a response time of 1 millisec. Envelope has provision for servo and flange mounting. Digitronics Corp., Albertson Ave., Albertson, L. I., N. Y.

For more information—
Circle 16, inside back cover



Four-way valve . . .

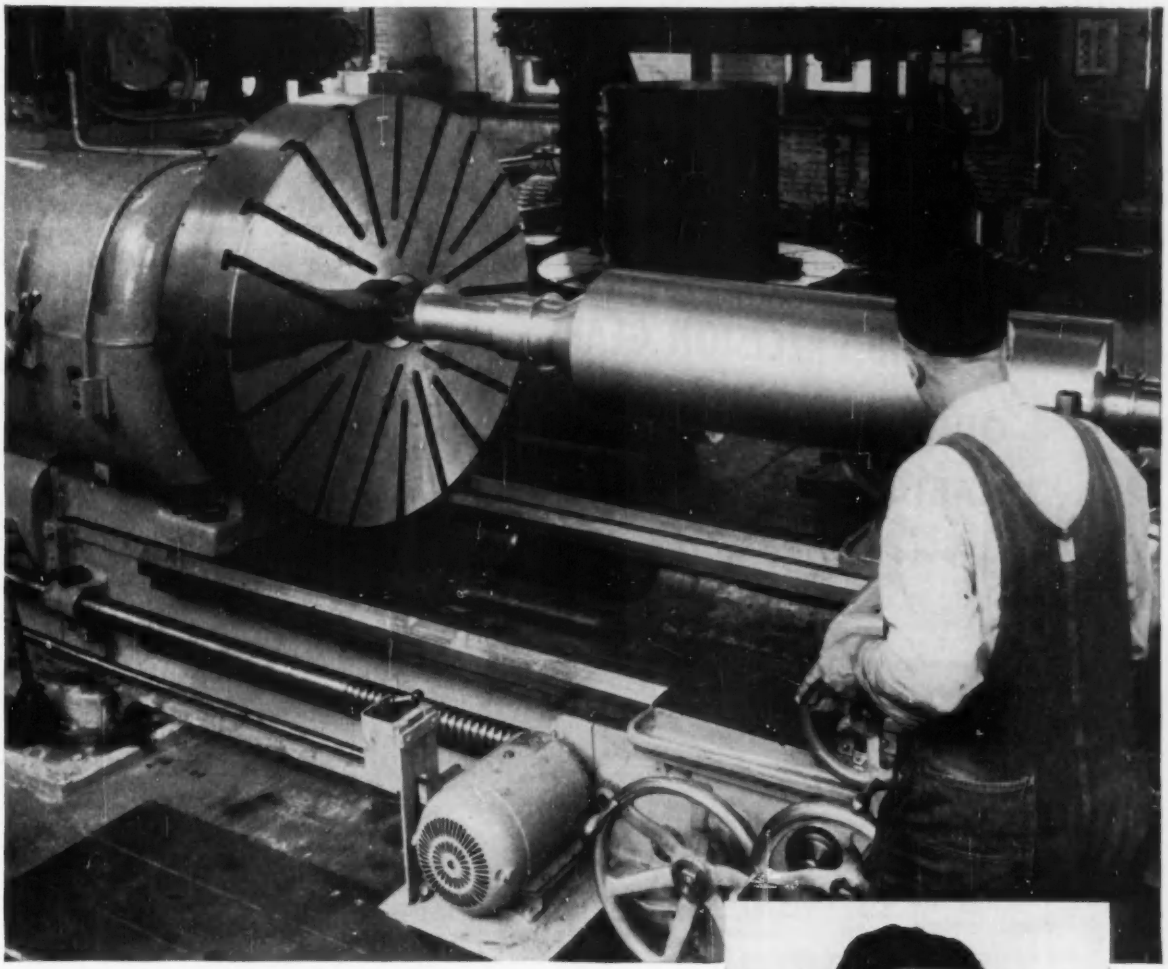
for liquids and gases comes in pipe sizes from $\frac{1}{4}$ to 1 in., but may be obtained with tube or any preferred special high-pressure connection. Withstands surges to 15,000 psi without damage to the valve's sealing qualities. Designed for a burst pressure of 30,000 psi. Self-aligning lapped seals prevents port-to-port leakage in the detented positions over a long period without frequent overhauling. No external leakage because pressure is confined to flow passages. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

For more information—
Circle 17, inside back cover

Rubber-to-metal adhesive . . .

provides a bond stronger than the rubber itself without the use of ovens. Cured in 24 hr at 77 F, it reaches maximum strength after 7 days. To reach maximum strength immediately, it may be cured in 4 hr at 120 to 140 F. Seven-day immersion tests in 10% hydrochloric acid, 3% sulphuric acid, 10% ammonium hydroxide or 10% sodium hydroxide shows

CONTINUED ON PAGE 138



"Standard Steel castings and forgings play an important role in the 'New Look' at Vulcan Iron Works"

We at Standard Steel Works feel justly proud of the fact that our castings and forgings play "an important role" in both the quality and service which our several hundred customers are rendering to *their* customers. Vulcan Iron Works is typical of our customers—it consistently meets the quality and delivery requirements of its customers, and knows it can rely on us to help maintain its leadership as rotary kiln manufacturers.

Why don't you present your next forging or casting requirements to us. You too will find that when we at Standard Steel Works say that we give equal emphasis to quality *and* service to our customers, we mean what we say. Write Dept. 4-J.

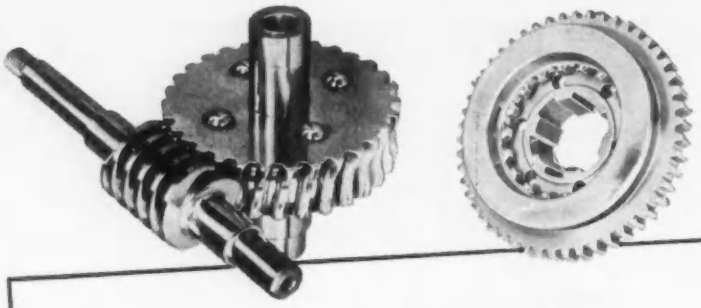
"When the new management took over at Vulcan, it immediately recognized the importance of better customer relations through faster deliveries and lower selling costs. Standard Steel's prompt service and quality products are helping Vulcan realize these objectives," says Mr. William J. Davis, plant superintendent, Vulcan Iron Works, Wilkes-Barre, Pa.

Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA

Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes



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—at a fraction of the price

When your gears are designed engineered and produced by SIER-BATH . . .

- **You get the ONE BEST GEAR DESIGN for each application,** giving your machines such improved performance and competitive advantages that increased sales follow naturally.
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- **You avoid early gear wear and failure.**

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Crown-Ground Spur and Helical Gears to 12" diameter, 4 pitch

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Sier-Bath PRECISION GEARS

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Made—cut—shaved—ground tooth
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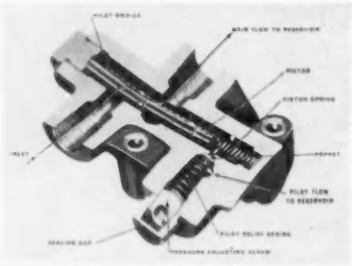
Also manufacturers of Rotary Pumps and Flexible Gear Couplings

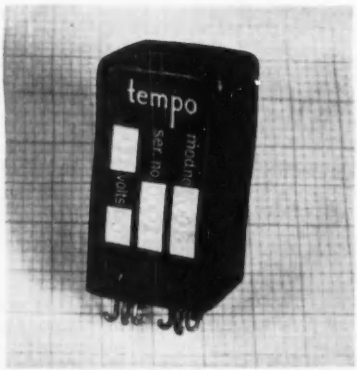
no visible effect on the bond. Rubber linings under peel or shear stress can be bonded for use to 100 F. Dielectric strength is 400-450 v/mm. The two-component adhesive consists of a synthetic resin base and an activator. Tensile strength is 2250 psi at 77 F. May also be used to bond metal, glass, ceramics or wood to metal and as a protective coating, sealing and casting compound. Adhesives Dept., Raybestos-Manhattan, Inc., Bridgeport 2, Conn.

For more information—
Circle 18, inside back cover



Pilot-operated relief valve . . . is said to be the answer to problems created by the working and operating loss resulting from psi differential between crack and full open in brute force-type valves. Valve is adjustable from 500 to 2000 psi and has a maximum capacity of 20 gpm. Has larger orifice to resist clogging. Over-all length of 4¼ in. permits mounting in limited space. Webster Electric Co., Racine, Wis.

For more information—
Circle 19, inside back cover



Subminiature time delay relays . . . avoid all moving parts except relay contacts through the use of transistors and time-constant circuits. Standard models are available with time delays from 0.01 to 60 sec, delay occurring between application of current and pull-in of relay

(Continued on page 142)

DUPONT

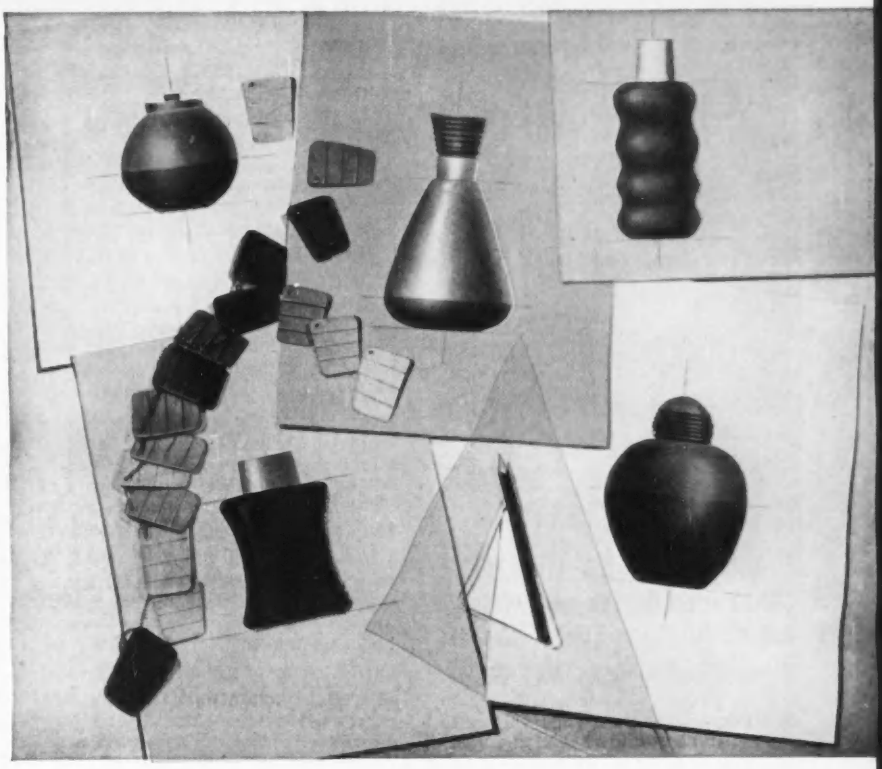
Better Things for Better Living ... through Chemistry

PRODUCT ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS:

ZYTEL®, TEFLON®, LUCITE®

Now, aerosol packages in colorful, new designs with ZYTEL® nylon resin



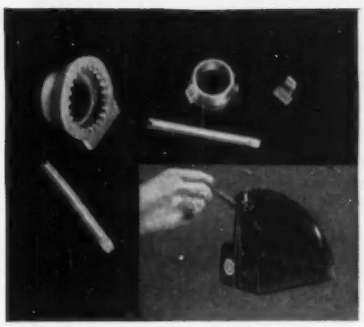
A new grade of ZYTEL nylon resin and a new fabricating technique are responsible for the entrance of DuPont ZYTEL into the aerosol packaging field. Now products can be marketed in aerosol packages which have exciting new shapes and attractive built-in colors.

The new grade of ZYTEL, type 42, is more viscous when melted . . . can be extruded easily in a form suitable for blow molding. Therefore, the use of ZYTEL permits an increased variety of functional and attractive designs.

The new technique of welding two injection-molded sections of ZYTEL permits the designer to vary his pigments and create eye-catching aerosol packages in a combination of beautiful colors.

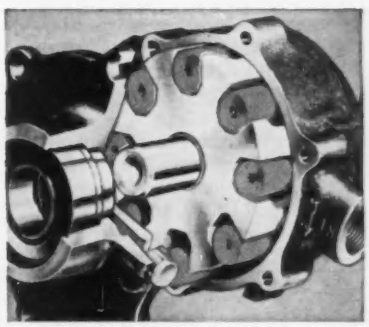
Aerosol packages of ZYTEL have a special appeal in the personal products field for colognes, hair lacquers and anti-perspirants. ZYTEL is impermeable to propellents . . . inert to chemicals found in many personal products. And because of the remarkable strength of ZYTEL nylon resin, the pressurized containers do not shatter, even when they are dropped on hard bathroom floors.

Property and application data on ZYTEL are available to you without cost or obligation. To get this information, simply clip and mail the coupon on the next page.



AUTOMATIC ELECTRIC PENCIL SHARPENER wears longer and operates more quietly due to its sturdy parts of ZYTEL nylon resin. Components of ZYTEL, such as the combined gear and bearing shown above, often replace complex metal assemblies without sacrifice in strength. In this way, ZYTEL helps to eliminate casting, machining, grinding and other operations that add to costs. Little or no lubrication is required for mechanical parts of ZYTEL. (Parts molded by The Ark Inc. for Stile-Craft Manufacturers, Inc., both of St. Louis, Missouri.)

BEARING SEALS of TEFLON tetrafluoroethylene resins are vital design features of the Floco Meter, assuring trouble-free performance. Used to measure the flow of crude oil, the meter requires a minimum of attention and maintenance. The bearing seals are unaffected by petroleum chemicals, temperature of the flowing oil, and suspended abrasives such as sand and grit. Waxes in the oils do not adhere to the surface of TEFLON, so that clogging is prevented. (Manufactured by Flow Equipment Company, Inc., Los Angeles, Calif.)



PUMP ROLLERS of ZYTEL nylon resin are unaffected by the insect, weed and cattle sprays or liquid fertilizers handled by this pump. A stainless-steel core is molded directly into each roller of ZYTEL. The rugged rollers resist wear at high pump pressures, even when handling liquids containing wettable powders. The heavy-duty pump slips directly onto tractor take-off shaft. (Rollers molded by Minneapolis Plastic Molders for Hypro Engineering Company, both of Minneapolis, Minnesota.)

OVER

DU PONT

Better Things for Better Living ... through Chemistry

PRODUCT ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS:

ZYTEL®, TEFLON®, LUCITE®

Because it is made of durable Du Pont LUCITE, the fashionable "Lady Schick" electric shaver will retain its sparkling, jewel-like appearance for years. (Molded and decorated by Hoosier Cardinal Corp., Evansville, Ind., for Schick, Inc., Lancaster, Pennsylvania.)

Beauty and durability of Du Pont LUCITE® lend sales appeal to "Lady Schick" shaver

Attractive, durable and economical, LUCITE acrylic resin is being used to add sales appeal to a wide variety of products. The "Lady Schick," for example, a new electric shaver for women, is exquisitely styled in sparkling LUCITE. And because of the remarkable strength and durability of LUCITE the shaver will retain its attractiveness for years.

Economically molded, LUCITE is used extensively in smartly styled appliances, household items and personal articles of all kinds. Because of its remarkable resistance to weathering and its outstanding optical properties, LUCITE also plays an important part in the lighting and sign industries.

Why not investigate LUCITE in terms of your own operation? To help you evaluate this remarkable material, we have prepared data that is yours without cost or obligation. Simply clip and mail the coupon below, and this information will be on its way to you.

Gaskets and packings made of TEFLON® resist corrosives tetrafluoroethylene resins and high temperatures

When you specify a TEFLON tetrafluoroethylene resin as the sealing material for your designs, you get the nearest approach to complete reliability for the majority of sealing conditions. You're sure that your seals aren't going to corrode or crumble under the attack of even the most powerful reagents. You're certain that you'll find your seals operating without failure at temperatures as high as 500°F. You're protected against any sign of seal embrittlement down to temperatures in the liquid-helium range. And you get the benefit of the low coefficient of friction of TEFLON resins, which greatly reduces torque at points such as shaft packing glands. Non-stick property makes it easy to open joints when necessary.

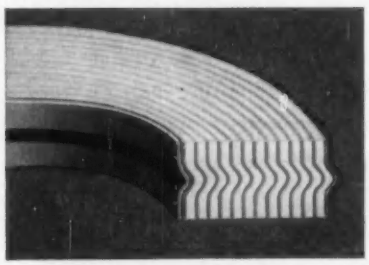
TEFLON tetrafluoroethylene resins are among the most inert chemical materials known to science. They are unaffected by nearly all chemicals and solvents in commercial use. The few exceptions to this include attack by the alkali metals under certain conditions. At high temperatures and pressures, halogens and certain halogenated chemicals and solvents may also affect them.

TEFLON resins are tough, flexible materials which can be accurately machined and molded. Most of the mechanical properties of solid TEFLON resins are comparable to those of the best grades of rubber-bonded compressed asbestos. High-pressure packing rings perform satisfactorily in 15,000 psi pumps. Seals, gaskets and packings of TEFLON tetrafluoroethylene resins operate reliably year after year, minimizing maintenance and replacement costs.

Send for the special literature we've prepared on this subject. It's packed with facts that can help you solve your sealing problems.

PACKINGS of TEFLON resins give uniform packing performance and long service life. Lubricity of TEFLON provides high mechanical efficiency.

ENVELOPE GASKETS consist of a soft filler covered by a jacket of a TEFLON tetrafluoroethylene resin. They are used for sealing large diameters and where bolting pressures must be limited, as in glass-lined equipment and pipe made from ceramics.



SPIRAL-WOUND GASKETS and gaskets made from asbestos and glass cloth impregnated with TEFLON resins are used in high-pressure installations such as pipe joints, reaction kettles, steam couplings, pump bodies, and pressure tanks.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 139, Du Pont Building, Wilmington 98, Delaware
In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec

Please send me more information on the Du Pont engineering materials checked: ☐ *ZYTEL;* ☐ *TEFLON;* ☐ *LUCITE. I am interested in evaluating these materials for:*

Name _____ *Position* _____
Company _____
Street _____
City _____ *State* _____
Type of Business _____

SEND FOR INFORMATION

For additional property and application data on LUCITE® acrylic resin, TEFLON® tetrafluoroethylene resins and ZYTEL® nylon resin, clip and mail this coupon.

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FORGINGS for...
the Jet-Missile Age
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KEY TO FORGINGS ILLUSTRATED
1. Jet Engine Pad — Titanium — 11 lbs. —17 inches.
2. Jet Engine Vane — Titanium — 27 lbs. — 15 inches.
3. Aircraft Support — Aluminum — 20 lbs. — 49 inches.
4. Aircraft Fitting — Aluminum — 282 lbs. — 86 inches.
5. Aircraft Landing Gear — Aluminum 284 lbs. — 47 inches.
6. Missile Ring Splice — Aluminum — 54 lbs. — 20 inches.
7. Aircraft Spar Frame — Aluminum — 434 lbs. — 142 inches.
8. Missile Fin — Aluminum — 8 lbs. — 30 inches.
Faster and faster, higher and higher — greater stresses, increased temperatures — all leading to continually increasing dependence on forgings — and in the forging field there is no substitute for Wyman-Gordon quality, experience and know-how.

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FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

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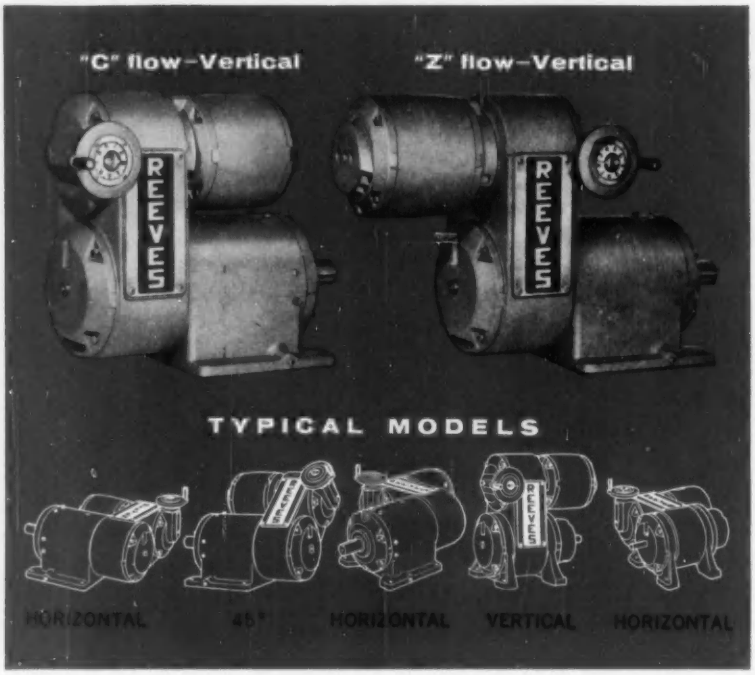
HARVEY, ILLINOIS • DETROIT, MICHIGAN

NEW **REEVES**®

*Sizes 200-300 Vari-Speed MOTODRIVES**

**200-300 Size, 1 through 5 hp.; full line, ¼ through 40 hp.*



The flexible design of these compact new REEVES variable speed power packages permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements. All models are available in both "C" flow and "Z" flow styles.

New increased capacity is built in the reducers—single, double or triple stages...new disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Complete information on all phases of the versatile 200-300 sizes Vari-Speed Motodrives is given in new Catalog. Write for your free copy today—Dept. 32-M571.

REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

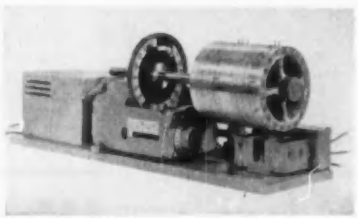
contacts. Timing accuracy is ± 10% of nominal through a temperature range of —55 C o 125 C. Withstands vibrations to 20G and 2000 cps and shock of 40 G for 11 millisec. Design provides instantaneous recycling. Input is from 18-31 v d-c. Contacts are double-pole, double-throw. Dimensions are 1 x 1 x 1¾ in. Weight is 2 oz. Tempo Instrument, Inc., 240 Old Country Rd., Hicksville, N. Y.

For more information—
Circle 20, inside back cover

Compression connectors . . .

reduce inventory requirements because they can be used on both aluminum and copper conductors. May be used to splice the different type conductors without danger of electrolytic action. Proper installation is simplified through a color-keyed system. Of high conductivity aluminum, connectors have hot-tin coating. The line consists of one and two-hole lugs and two-way connectors from 8 AWG to 1000 MCM. Sizes from 4/0 to 1000 MCM are installed without a hydraulic tool. Thomas & Betts Co., 36 Butler St., Elizabeth, N. J.

For more information—
Circle 21, inside back cover



Adjustable program timer . . .

can be furnished for any time cycle up to 4000 sec (66⅔ min). Ranges are specified in 100-sec brackets. The overall time cycle is adjustable in 1-sec increments from zero to one-half the maximum range;

(Continued on page 146)

PYRAMIDING DESIGN TALENT

Thin sections, holes, bosses, metal savers, odd shapes all produced in a split second—from molten metal. No other process can compete with this for eye appeal or low cost.

with MADISON-KIPP zinc and aluminum die castings

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Please clip this ad as a reminder to contact us when you have die casting requirements.

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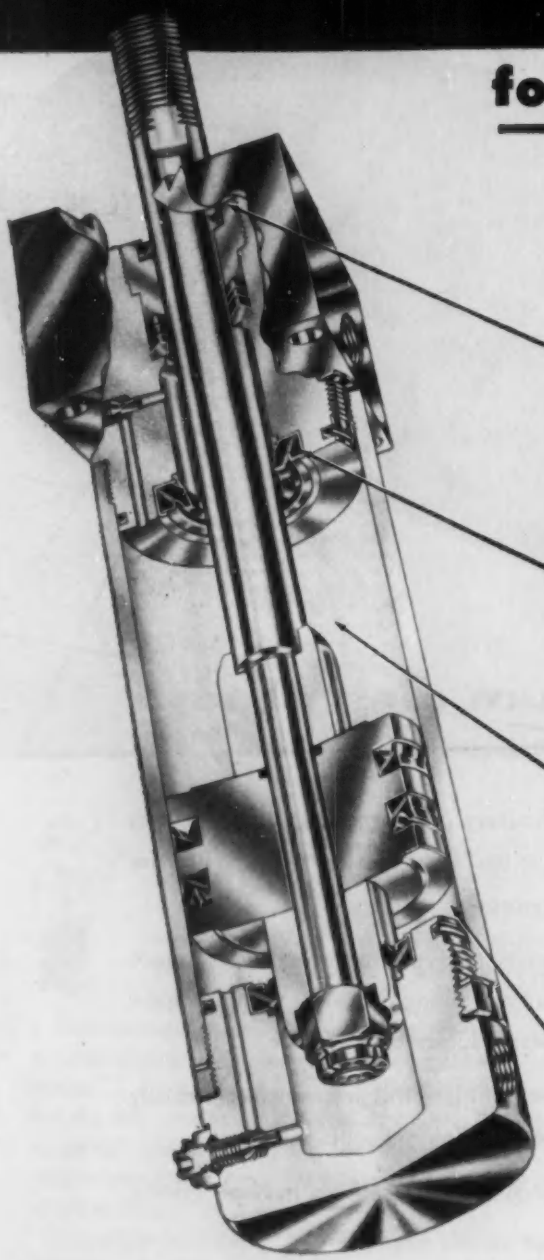
Need a cylinder today?

for all these Extras . . .

T-J Spacemaker



PISTON ROD SCRAPER . . . Not just a felt or fabric wiper, but a metal to metal contact. Protects rod packing and cylinder bores at all times by actually removing foreign particles from piston rod surface. STANDARD AT NO EXTRA COST!

NEW "SUPER" CUSHION FOR AIR . . . Of T-J design and patent, it assures millions of trouble-free cycles. Years of T-J research and test have answered the problem of "how to make a cushion last". All T-J cushions are adjustable, STANDARD AT NO EXTRA COST!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . The piston rod, of course. But of these two features, the chrome plated bore is by far the most important, due to the much greater area that is subject to wear. Chrome plating of bore gives extra protection where needed most. Also a protection from condensation and foreign matter, that may find itself into the system. STANDARD AT NO EXTRA COST!

ONE PIECE PISTON . . . Giving you three point surface bearing which increases the distance from the piston end to the rod bearing. This T-J feature assures better alignment, longer bearing and packing life. STANDARD AT NO EXTRA COST!

off shelf delivery

. . . Just call T-J

at no Extra Cost!

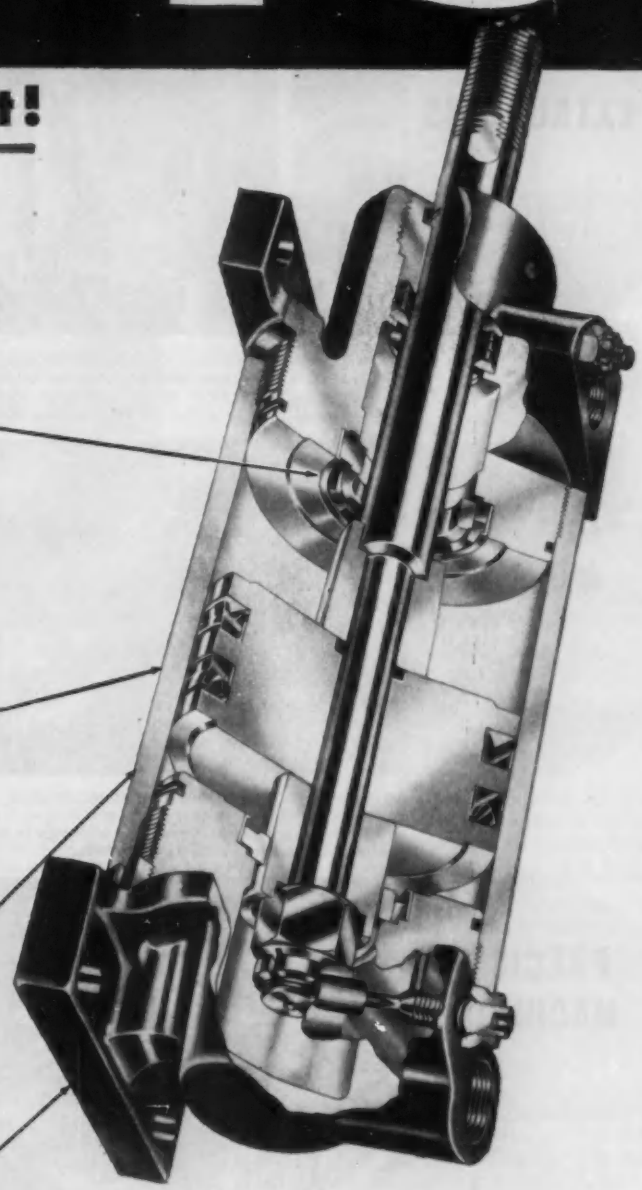
cylinders

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . (Pat. Applied For) New T-J cushion design eliminates problems of worn out, or out-of-line cushion seals. Eliminates need of a ball check while greatly increasing the return flow, assuring fast breakaway on return stroke. All T-J cushions are adjustable, STANDARD AT NO EXTRA COST!

NO TIE RODS TO STRETCH . . . By eliminating tie rods, the T-J SPACEMAKER gives you 360 degree port rotation, streamlined design, no tie rod stretch, without sacrificing strength. STANDARD AT NO EXTRA COST!

STREAMLINED DESIGN . . . Minimum center-line to center-line mounting—years ahead and in keeping with modern trends. Easy to clean for an extra appearance on your machine, without sacrificing strength. Oil pressure to 750 P. S. I.—air to 200 P. S. I. STANDARD AT NO EXTRA COST!

FORGED SOLID STEEL HEADS . . . (4″ bore through 8″ bore) Requires no additional mounting brackets, because mounting holes are a part of the one piece solid forged steel head. Its design lends itself to smooth streamlined modern appearance. STANDARD AT NO EXTRA COST!



WRITE TODAY for new bulletin with complete details of the T-J Spacemaker line, or call Jackson; Michigan, State 2-0462.

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RIVITORS . . . AIR AND HYDRAULIC CYLINDERS . . . REAMERS . . . CUTTERS . . . CLINCHORS

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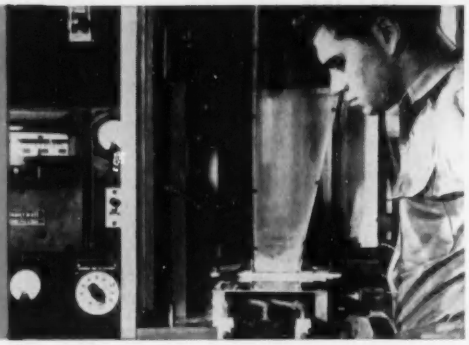
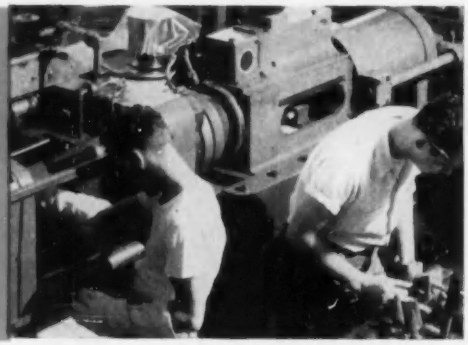
EXTRUSIONS
rods, tubing, sheets, tape



A new ultra-modern extrusion plant produces bubble-free nylon rod up to 3" dia.; nylon sheet and tape up to 12" wide, in thicknesses from .002" to ⅛"; and nylon hydraulic tubing from ⅛" O.D. to ½" O.D. for 1000 psi and 2500 psi.

INJECTION MOLDINGS
mass produced at low cost



An extensive, ultra-modern injection molding plant equipped with machines ranging in capacities up to 8 oz., and specializing in difficult precision moldings in volume production with accompanying economies.

PRECISION MACHINING
on high speed automatics

A complete, high-speed plastics machining plant, geared to the production of innumerable nylon parts to manufacturers' specifications. Whatever your nylon part requirements—check your methods and costs with U.S.G. "Know-how."

United States Gasket Company
Camden 1, New Jersey

United States Gasket *Plastics Division*
OF THE GARLOCK PACKING COMPANY

in 2-sec increments from one-half to full range. The number of switching events is limited only by the length of the time cycle setting. Maximum would be one per second. Any selected switching program is recycled automatically. When operated on a line having a controlled frequency of 60 cps, switching accuracy can be held within $\pm\frac{1}{10}$ sec. Motor is rated at 115 v, single phase. Counter & Control Corp., 5213 W. Electric Ave., Milwaukee 14, Wis.

For more information—
Circle 22, inside back cover

Electronic timer . . .

has stop-motion control, self-reset timing with several units in sequence, momentary start with non-repeat feature, sustained starting with immediate reset, emergency timing-out, adjustable timing between fixed pulses, d-c starting relay for use of 115 v, 25-400 cps, a-c, load contacts isolated from timer and line circuits, two sets of single-pole, double-throw 8 amp contacts, identical enclosed plug-in d-c relays. Cold-cathode instant-starting tube is energized only momentarily at the end of time cycle, with immediate recycling. Eight time ranges are available: 0.2, 0.5, 1.0, 3.0, 6.0, 12.0 or 24 sec. Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.

For more information—
Circle 23, inside back cover

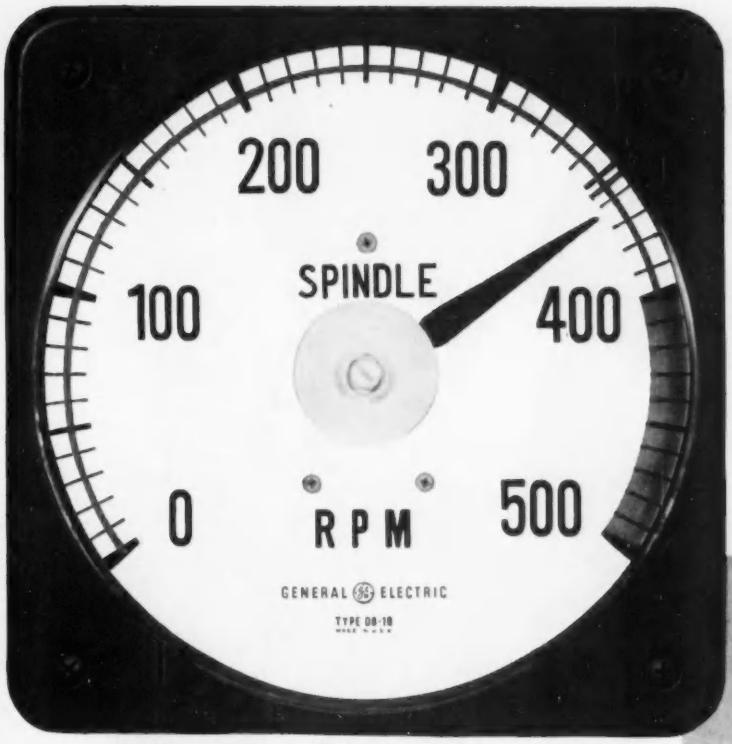
Throttling valve . . .

is controlled by a pilot needle valve with low turning torque. It is being built in the 1 in. size. Operator adjusts small needle valve to control a balanced piston. Full flow is obtained by 2¼ turns of the pilot valve, yet metering is accurate to 1/1000 gal per minute through entire range of the valve. Body is aluminum alloy with stem, inserted seal and piston

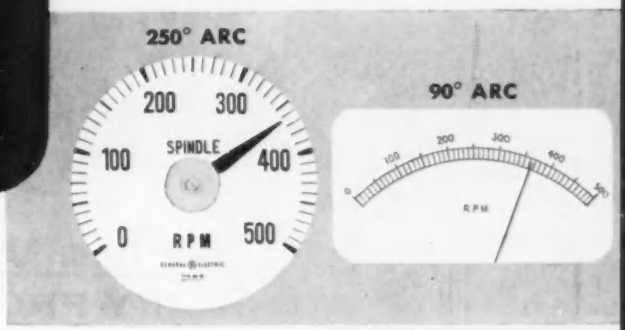
(Continued on page 148)

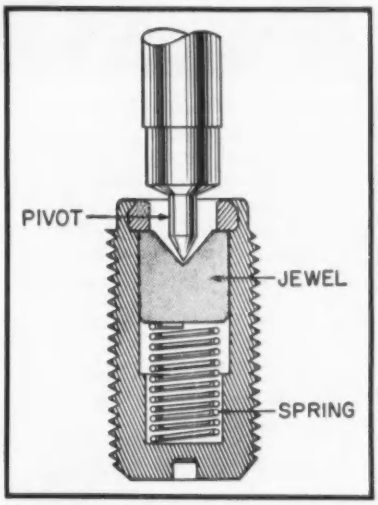
GENERAL ELECTRIC
SPEED-MEASURING SYSTEMS OFFER:

Improved Readability; Shock-Resistant Pivot Design



ACTUAL SIZE photo of G-E 4¼" speed indicator shows ease of readability made possible by shadow-proof glass, 250-degree scale, and large numerals. See the difference that the longer scale and larger numerals make (right). This design is also available in an 8¾-inch instrument.





SHOCK-RESISTANT, G-E long-scale instruments utilize spring-mounted jewels to cushion pressure on pivot points. Bevel-shouldered pivots ride against retainers to help protect against "mushrooming."

Improved readability and sustained accuracy even under difficult conditions of shock and vibration are two major benefits of the long-scale speed-measuring instruments. Used with any of the complete line of General Electric a-c or d-c tachometer generators, these handsome indicators provide a speed-measuring system with features unmatched by other equipment.

SHOCK RESISTING PIVOT DESIGN

Sustained accuracy of reading even under difficult conditions is made possible by the shock resisting spring-mounted jewel and pivot design of these instruments. This construction practically eliminates pivot "mushrooming" and resultant sticky pointer action caused by shock and vibration incurred in high-speed applications.

SYSTEM ACCURACY OF ±1%

All General Electric speed-measuring systems incorporating long-scale instruments are factory calibrated for an accuracy of ±1% of full scale. Any errors that occur in a-c systems due to rectifier aging can be eliminated by periodic adjusting of the rheostat at the base of the indicator, another exclusive feature.

RECORDERS ALSO AVAILABLE

For recording and controlling speed, General Electric also offers a line of electronic, servo-operated, round-chart recorders and recording controllers. Special circuits are available for measuring differential speed, speed ratio, speed deviation from a fixed reference, and the reciprocal of speed or "time in process." For some models, accuracy is as high as 0.1% of measured speed.

For recording only, you can use General Electric's versatile CH recorder with the enclosed, throw-away inkwell that minimizes spilling and eliminates cleaning.

WRITE FOR BULLETINS

For more detailed information, call your nearest General Electric Apparatus Sales Office or write for descriptive bulletins to Section 585-71A, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

GEARS by FAIRFIELD

A Plus Value IN ANY PRODUCT!

If GEARS are a vital part of the product you make, there is no finer recommendation for the QUALITY of your product than to be able to say it is equipped with "FAIRFIELD GEARS."

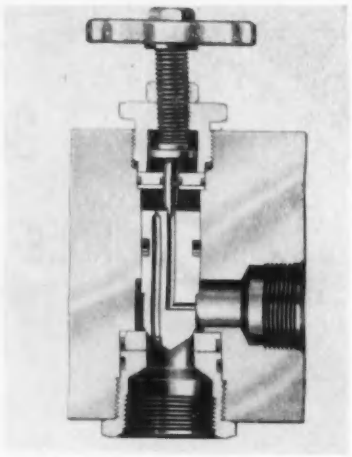
Long producers of the gears needed in high grade trucks and tractors, Fairfield now brings the same standards for GEAR PERFORMANCE to a wide variety of products: Agricultural Implements . . . Power Shovels . . . Machine Tools . . . Diesel Locomotives . . . Road Graders . . . Lift Trucks . . . Road Rollers . . . Pump Drives . . . Winches . . . Military Vehicles . . . and a host of others.

Fairfield's facilities are unexcelled. Here "under one roof" in a new and ultra modern plant, Fairfield has everything needed for producing all kinds of gears: spur . . . herringbone . . . spiral bevel . . . ground tooth spiral bevel . . . straight bevel . . . coniflex bevel . . . hypoid . . . zerol . . . worms and worm gears . . . splined shafts . . . differentials. Get acquainted with Fairfield—your inquiry will receive prompt attention.

Send for illustrated bulletin describing Fairfield's facilities.

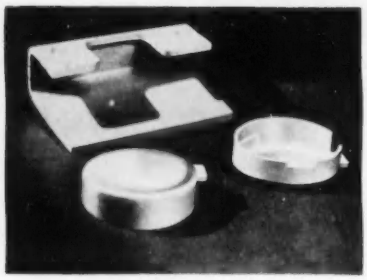
FAIRFIELD
MANUFACTURING CO.
2305 S. Concord Rd.,
Lafayette, Indiana

For FINE GEARS



of hardened stainless steel. Standard with O-ring seal, internal straight thread connections and hydraulic oil seals. Republic Mfg. Co., 15655 Brookpark Rd., Cleveland 11, Ohio.

For more information—
Circle 24, inside back cover



Epoxy resin parts . . .

molded or cast, are now available on a production basis. Process gives high gloss finish, with good reproductibility; tolerances of —0.002 in. Moldings can be used from —100 F to 300 F. Can be provided in colors. Combs Eng. & Mfg. Co., 428 S. Cherry St., Wallingford, Conn.

For more information—
Circle 25, inside back cover

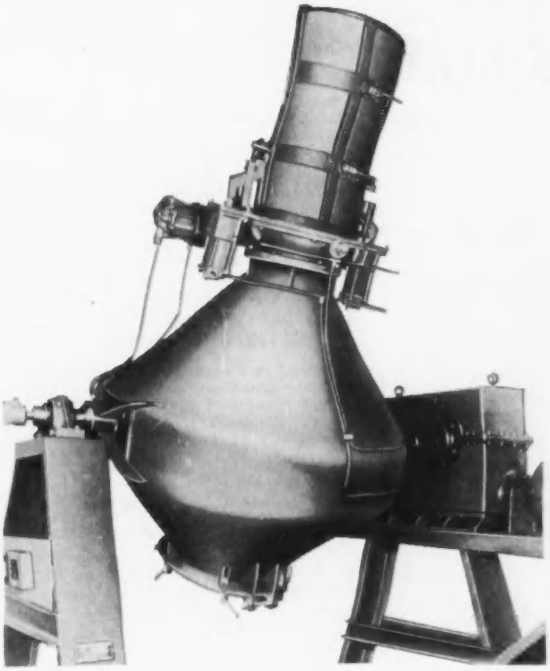
Flexible magnetic shielding foil . . .

has been developed for low and high frequencies at low intensities. Available from stock in 0.004 and 0.007 in. thicknesses. Foil offered in rolls to 2.5 in. and 14 in. wide depending on type. Foil cuts with scissors to any required shape or size. Bends easily and remains in the bent shape.

May be used for transformer and cable wrapping, lining the inside of vibrator and relay cans, vacuum tube shielding, lining the inside of cabinets to minimize hum

(Continued on page 152)

How ORANGE *STAGGERED* ROLLER BEARINGS meet unusually rugged, precision requirements in Gemco Conical Blenders



"Over 10 years service without a replacement in any unit", reports General Machine Company, Newark, N. J.

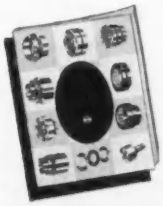
The speed reducers and pillow blocks of all Gemco Large Capacity Conical Blenders are engineered to efficiently handle the "tumble-over and spread action" of the blender. To withstand such severe treatment, and to handle extremes of 25,000 lb. load capacities, Orange "Staggered" Roller Bearings have been installed in these critical operating areas of Gemco Blenders since 1946, providing outstanding performance and eliminating maintenance and failure.

For extra heavy loads—severe service conditions—and to assure continuous trouble-free operation over years of heavy-duty operation, install Orange "Staggered" Roller Bearings.

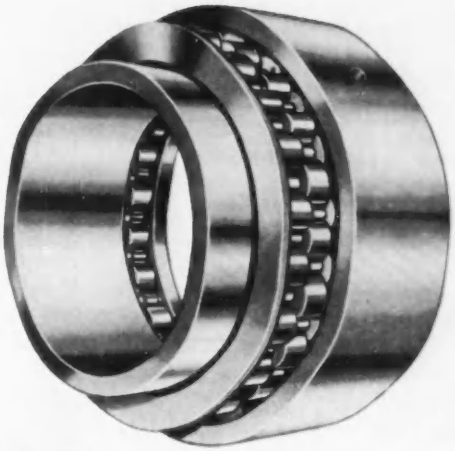
The exclusive staggered and meshed short roller arrangement, in place of conventional long rollers, gives this bearing many advantages:

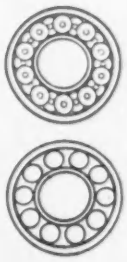
- **Extremely high load-carrying capacities**
- **Even distribution of raceway load over a maximum of contact points**
- **Multiple short rollers minimize skewing tendencies of fewer long rollers**
- **Longer bearing life under severe stress**
- **Solves design problems—cuts costs—saves space because smaller sizes often can be used.**

Orange "Staggered" Roller Bearings are available in a full range of standard sizes, fully interchangeable with other bearings in the 200 and 300 series. Engineering service and stocks in all industrial centers.



Write for 40-page Engineering Manual M-56 to obtain detailed information on the complete line of Orange Roller Bearings.





End views of an Orange "Staggered" Roller Bearing (upper) and a conventional bearing (lower) show graphically how many short rollers provide a multiplicity of contact points within the loaded zone.

ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
551 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

Fastener Facts

by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

DESIGN PRODUCTION & PURCHASING DATA

HOW TO MAKE BOTH ENDS NEAT

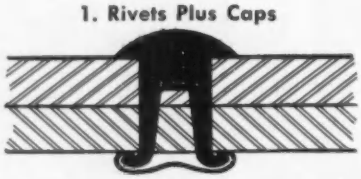
Is This Your Problem?

When both ends of a fastener can be seen and touched, it's often a problem to design an assembly that has neat lines and smooth surfaces.

Two Solutions:

The rivets pictured above show two popular means of making both ends neat. The most common way is to clinch the rivet inside a cap that looks like the head. The greater bearing surface provided by the caps prevents rivets from tearing loose and also strengthens materials. The other method is to use compression rivets, consisting of accurately matched pairs of solid and deep-drilled rivets that give a secure pressed fit.

1. Rivets Plus Caps



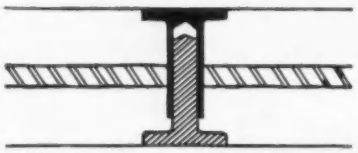
Thomson Standard Caps are made of steel and brass in diameters ranging from ¼" to 9/16" with flat or concave backs. They can be finished or japan-colored to match the self-piercing Thomson Deep-Drilled or Bifurcated (Split) Rivets of your choice.

Clinch strength with caps depends on your choice of rivet. The scored clinch of deep-drilled rivets is much stronger than the two-legged clinch of split rivets of the same diameter.

Thomson Caps are applied by a two-hopper machine that automatically feeds and sets all standard sizes of Thomson Deep-Drilled and Split Rivets and their matching caps. Hand-fed machines are also available.

Thomson Machines, in both bench and floor models, can be had to meet your special requirements.

2. Compression Rivets



Thomson Compression Rivets come in precision-made male and female pairs. Each pair consists of a solid rivet with chamfered shank and a deep-drilled rivet to match. Because their most common use is for attaching handles to knives, they are often called "Cutlery Rivets".

Thomson Compression Rivets — cold headed from aluminum, brass, nickel silver and steel — are designed to seat snugly in counterbored holes. So, they give a smooth, projectionless surface to the product or assembly. They also provide the strongest pressed fit in the rivet industry. Heads may be trimmed in a secondary operation when more critical tolerances are required.

You have a choice of Thomson Rivet-Setting Machines for applying Compression Rivets: Thomson Knife Handle Machine (Style 137A) or two standard Thomson Rivet-Setting Machines (Style 161) in tandem.

Style 137A Style 161

The Thomson Knife Handle Machine is a versatile special-purpose machine that inserts male and female rivets into assemblies in a single operation. It handles rivets with heads up to 3/16" diameter . . . and lengths up to 1". Its arm is adjustable for the various assembly thicknesses and rivets lengths within its capacity.

When two standard Thomson Rivet-Setting Machines are used, one inserts the deep-drilled rivet; the other sets the solid rivet into the mate's hollow shank.

Complete Line:

Whatever your fastening problem, there's a Thomson Rivet that will cut costs and speed assembly. More than 800 stocked standards and more than 8000 standards in print-form promise you the kind of service that saves time and money.

More than 250 styles of Thomson Rivet-Setting Machines also offer you the advantages of high production rates on your assembly lines. The machine of your choice is custom-tooled for your application and factory-tested on actual samples before shipment. Available on a purchase or lease basis.

Design and Engineering Service

Thomson analyzes your fastening problems and makes specific rivet and machine recommendations . . . at little or no cost. When called in before designs are frozen, our engineers can help you design around standard rivets and machines that cut costs and speed assembly. Thomson also saves time and money on your current fastening jobs by giving you a choice of more than 800 standard rivet types and sizes. Submit sketches, prints or samples for recommendations and quotations.

Free "Fastener Fact File"

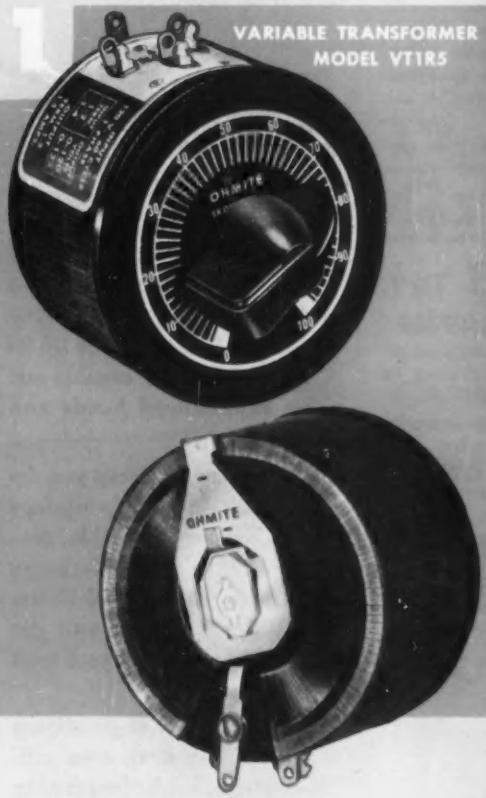
This authoritative manual on all phases of riveting is "must" reading for anybody responsible for specifying or buying low-cost fasteners. It covers rivet types, applications, materials, finishes and other factors that simplify selection of the right rivet machine for any job. For your free copy, write: Judson L. Thomson Mfg. Co., Dept. C, Waltham 54, Mass.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

2 new components from OHMITE®

subminiature wire-type tantalum capacitors and variable transformer

1 VARIABLE TRANSFORMER MODEL VT1R5



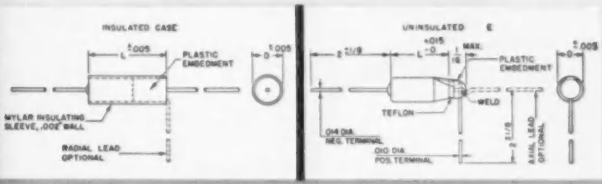
MORE CAPACITY FOR EQUAL SIZE

The rating of 1½ amperes represents a continuous rating at any brush setting. This "bonus" in current capacity is the result of a unique core design by Ohmite. The new Ohmite VARIABLE TRANSFORMER model VT1R5 features: Long-wearing, nonoxidizing, rhodium-plated coil contact surface, a ceramic hub that mounts the contact arm, and provides 3000 VAC insulation between parts at line potential and shaft assembly; positive brush to center-lead connection because brush pigtail shunt is bonded into solid copper-graphite slip ring. Input voltage is 120 V, 60 cycle; output voltage is 0-120 V—0-132 V. Mounted by ⅜"-32" bushing and nut. *Write for Bulletin 151.*

2 TANTALUM CAPACITORS SERIES TW

GREATER CAPACITANCE PER UNIT VOLUME

The new Series TW Ohmite subminiature Tan-O-Mite® TANTALUM CAPACITORS are wire-type units that feature greater capacitance per unit volume, lower leakage current and power factor, and small capacitance drop at extremely low temperatures as compared to other types of electrolytics. Ultrasmall for low-voltage DC transistorized electronic equipment, these new tantalum capacitors have *high stability, high capacitance, long shelf life,* and excellent performance under temperature extremes of −55° C to +85° C. They are available in six *subminiature sizes:* 0.1 to 60 mfd. over-all capacitance range.



SIZE	UNINSULATED		INSULATED	
	D (inches)	L (inches)	D	L
T	.075 (5/64)	.156 (5/32)	.082	.203
S	.075 (5/64)	.187 (3/16)	.082	.234
M	.095 (3/32)	.172 (11/64)	.100	.218
A	.095 (3/32)	.250 (1/4)	.100	.312
B	.125 (1/8)	.312 (5/16)	.134	.375
C	.125 (1/8)	.500 (1/2)	.134	.562

Smallest size is .075 (5/64) x .156 (5/32) inches; the largest is .125 (1/8) x .500 (1/2) inches. Five stock sizes are available in a wide range of capacitances, voltages. Units insulated with a tough Mylar® plastic sleeve can be furnished. *Write on company letterhead for Bulletin 148B.*

BE RIGHT WITH

OHMITE®

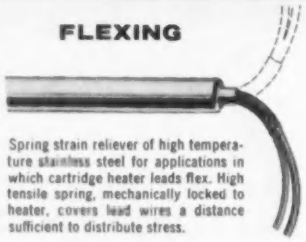
RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES
TANTALUM CAPACITORS • VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3611 Howard Street, Skokie, Illinois

TAKE YOUR PICK!

Special Chromalox features solve 3 spot heating problems

FLEXING

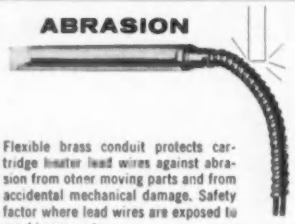


Spring strain reliever of high temperature stainless steel for applications in which cartridge heater leads flex. High tensile spring, mechanically locked to heater, covers lead wires a distance sufficient to distribute stress.

MOISTURE

Moisture-resistant flexible brass conduit protects lead wires of cartridge heaters operating in presence of steam, water, oil and vapors. Also offers added protection from flexing, vibration and mechanical damage

ABRASION



Flexible brass conduit protects cartridge heater lead wires against abrasion from other moving parts and from accidental mechanical damage. Safety factor where lead wires are exposed to machine operator.

FREE BULLETIN!

CHROMALOX ELECTRIC CARTRIDGE HEATERS

Get the full story. Call your Chromalox Representative or write today for Bulletin 850.

C-2101

Edwin L. Wiegand Company

7535 Thomas Boulevard • Pittsburgh 8, Pa.

and for spiral wrapping paper tubing. Magnetic Shield Div., Perfection Mica Co., 1322 N. Elston Ave., Chicago 22, Ill.

For more information—
Circle 26, inside back cover

Ready-mixed aluminum paint . . .

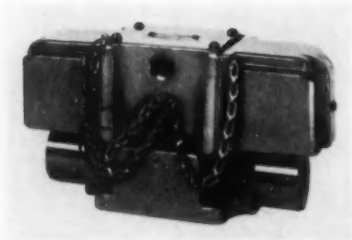
air dries in approximately 3 min. It is formulated from synthetic thermoplastic resins and 325 mesh aluminum pigment, and adheres to metals, plastics, glass, rubber and wood. Atmospheric conditions such as temperature or humidity do not affect drying time. Coverage is approximately 650 sq ft per gal. Application may be by brush or spray equipment. Alumatone Corp., Los Angeles, Calif.

For more information—
Circle 27, inside back cover

Double-surfaced white tracing cloth . . .

allows unchanging parts of a drawing to be drawn on one of its sides and details subject to repeated revision and erasure to be drawn on the other. The water-repellent cloth can take pencil lines as hard as 9H and repeated erasures. In all sheet sizes and 20 yd rolls, 30, 36 or 42 in. wide. Charles Bruning Co., Inc., 4700 W. Montrose Ave., Chicago 41, Ill.

For more information—
Circle 28, inside back cover

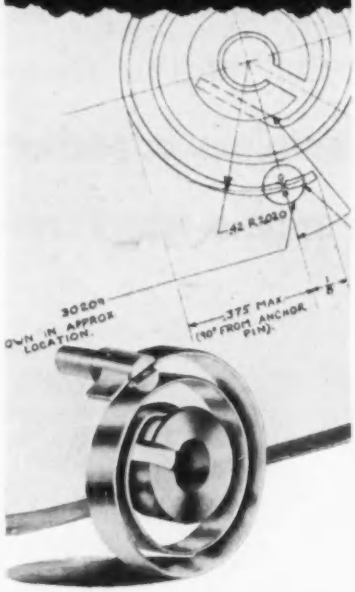


Solenoid controlled, pilot-operated, four-way valves . . .

in a new small size to fill the void between ¼ and ⅜ in. IPS. Three models include a double solenoid, no spring (10¼ x 3¾ x 5 in.); a single solenoid spring offset (8¼ x 3¾ x 5 in.); a double solenoid spring cen-

(Continued on page 156)

RIGID SPRING SPECS?



We're used to them here at John Chatillon & Sons. Specifications calling for incredibly close tolerances and little-known alloys are capably met by experienced hands and brains.

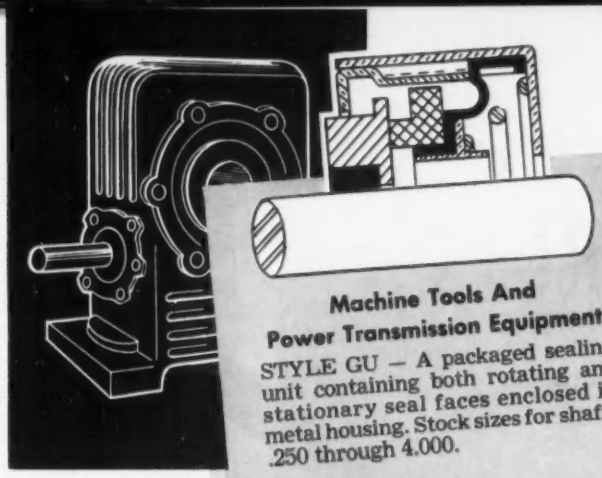
When the machinery you design calls for precision springs seemingly not available, consult with the Spring Engineers at John Chatillon & Sons. You'll save time, and get springs designed for your most exacting needs.

Over 120 years of experience and training await your call. Get into the habit of contacting Chatillon . . . Write Department D-3.

JOHN CHATILLON & SONS

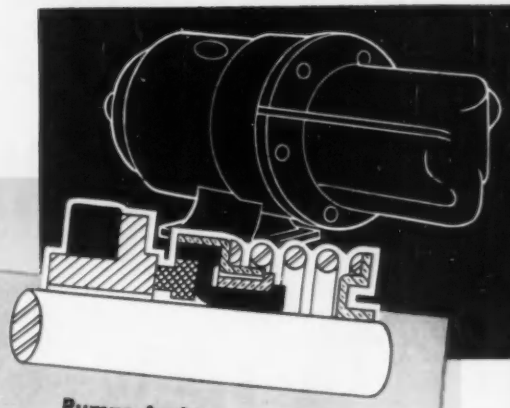
85 CLIFF STREET, NEW YORK, N. Y.

Manufacturers of Precision Springs and Force Measuring Instruments Since 1835.



Machine Tools And Power Transmission Equipment

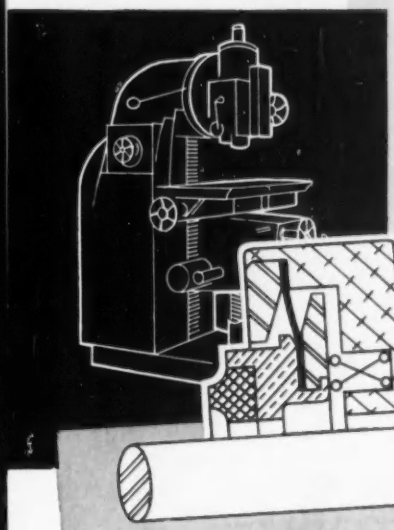
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line

GITS SHAFT SEALS

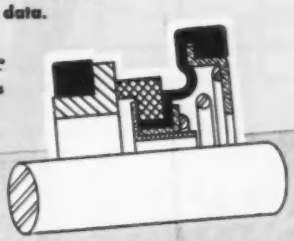
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

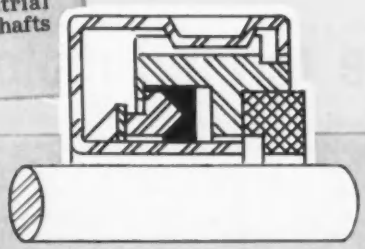
1638B South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



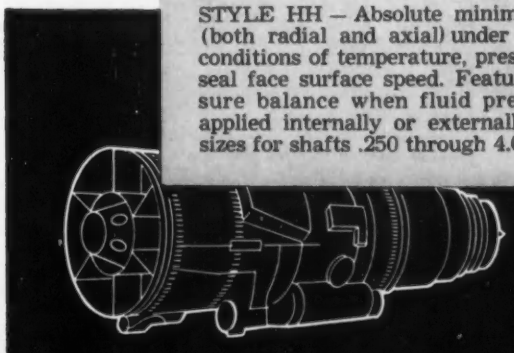
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

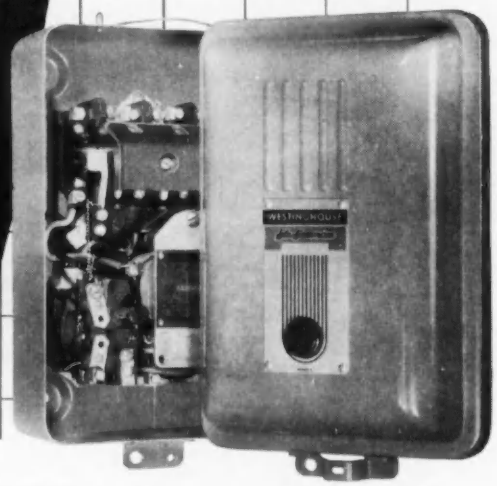
STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



MORE HORSEPOWER!

LESS COST!

SMALLER SPACE!



with Westinghouse rerated motor starters

Here's real news for cost-conscious, space-conscious electrical planners.

Westinghouse Life-Linestarters® (sizes 0 and 1) *have been uprated*... giving you the advantages of more horsepower, less space, lower cost!

For example: if you've been controlling a 440-volt, 5-hp polyphase motor with a size 1 starter, you can get the identical control and protection with the smaller, less costly size 0 starter.

And speaking of performance...

Only Westinghouse starters have the De-ion® arc quencher, which greatly increases contact life by reducing burning and pitting.

Westinghouse starters utilize high-strength, non-carbonizing Rosite insulating parts for maximum safety and operating life.

Westinghouse starters have double-break, silver-to-silver contacts for longer life and greater dependability.

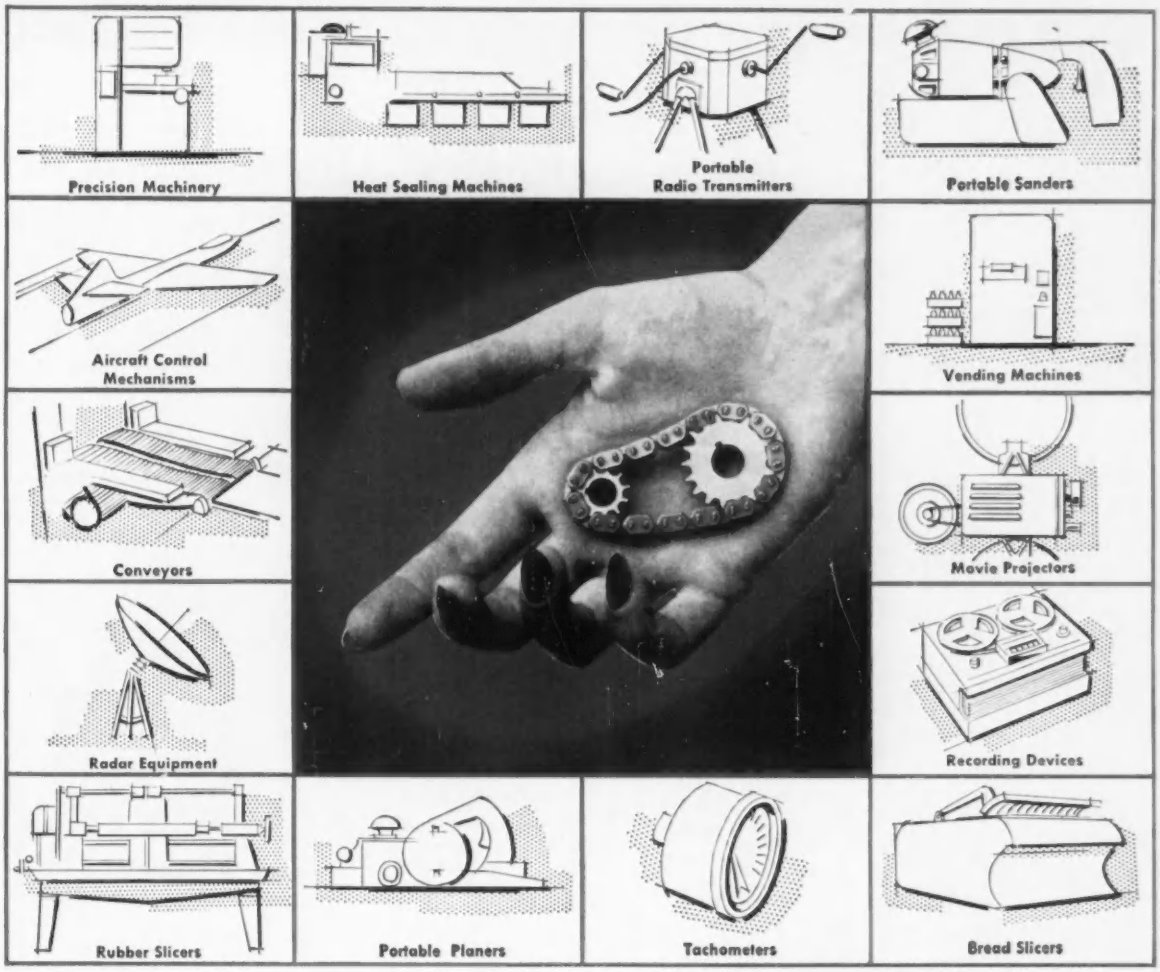
What's more, the entire starter line is designed to simplify installation and maintenance — featuring front-removable parts and straight-through wiring.

For the full story, contact your nearby Westinghouse sales office. Or write Westinghouse Electric Corporation, Standard Control Division, Beaver, Penna. J-30280

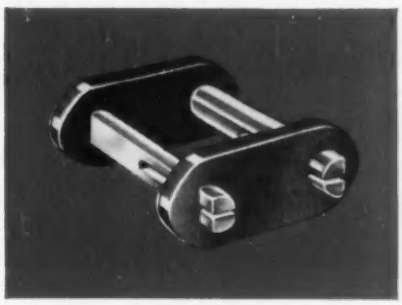
NEMA SIZE	110 Volt				220 Volt				440-600 Volt			
	1ø		3ø		1ø		3ø		1ø		3ø	
	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating
0	1	1	1½	2	1½	2	2	3	1½	3	3	5
1	1½	2	3	3	3	3	5	7½	5	5	7½	10

Westinghouse uprated starters give you: More horsepower — in eight new starter ratings. Less cost and space — in applications where the rerated size 0 starter replaces the size 1 starter, and the size 1 replaces the size 2.

YOU CAN BE SURE... IF IT'S Westinghouse



MORSE'S TINIEST CHAIN GIVES POSITIVE DRIVES UP TO 10,000 RPM . . . AND IN LIMITED SPACE!



EXCLUSIVE!

Patented coupling link makes assembly and removal of Morse 3/16"-pitch Silent Chain easy, permits design of fixed center drives without assembly problems. Your Morse distributor can supply you with exact lengths needed; or you can buy chain in bulk, cut it to size, assemble it yourself with easy-on coupling links.

Trying to get more components into less space? Morse 3/16"-pitch Silent Chain helps you do it—often saves you money, too!

Tiny, but with the strength of steel, these highly efficient drives transmit power as smoothly as a belt at speeds up to 10,000 rpm. Split-second precision of drive frequently permits replacement of costly gears.

You can get Morse 3/16"-pitch Silent Chain in every standard style: shroud, center guide, or duplex; special chain materials are available for use in corrosive or extremely wearing conditions. For skilled engineering help on power transmission in limited space, call your local Morse distributor today. He's listed in the Yellow Pages under "Power Transmission." Or write: *MORSE CHAIN COMPANY, DEPARTMENT 4-97, ITHACA, NEW YORK; Export Sales: Borg-Warner International, Chicago 3, Illinois.*

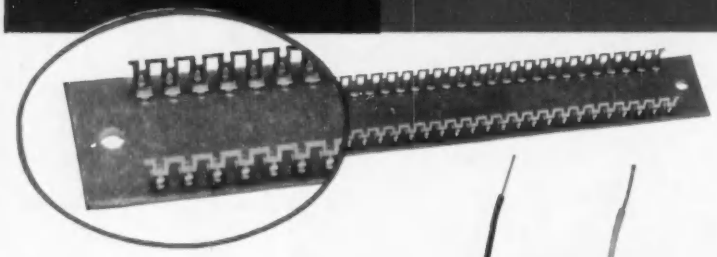
IN POWER TRANSMISSION
THE TOUGH JOBS COME TO

MORSE MORSE BW

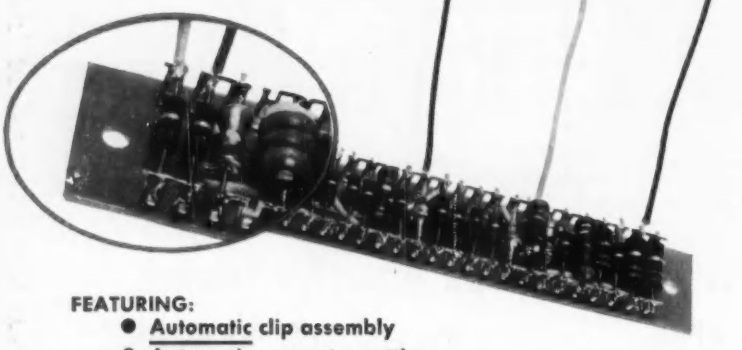
*Trademark

another *New* concept in component packaging . . .

by ERIE Electro-Mechanical DIVISION



THE ERIE STRIP PACKAGE SYSTEM



FEATURING:

- **Automatic clip assembly**
- **Automatic connector cutting**
- **Automatic component soldering**

RESULTS:

- **Lower production costs**
- **Higher reliability in solder connections**
- **Easier servicing**

ERIE supplies the customers' complete component package: electronic components, molded plastic parts, metal stampings, and embossed wiring boards available from various ERIE divisions; as well as other components purchased from other manufacturers.

For more complete information regarding the ERIE 3976 Strip Package, and its practical application in the solution of your individual problems, write to Engineering Department, Electro-Mechanical Division, Erie Resistor Corporation.

ERIE electro-mechanical

ERIE ELECTRO-MECHANICAL DIVISION
ERIE RESISTOR CORPORATION
Main Offices: **ERIE, PA.**
Factories: **ERIE, PA. • HAWTHORNE, CALIF.**

tered (10¼ x 3¾ x 5 in.). Though valves are shorter than direct solenoid valves, flow capacity is said to be greater. Valves use same solenoids as ⅛ or ¼ in. models, thereby permitting use of the same solenoids throughout the circuit where different sized valves are used. Surges in the tank line will not affect new valve operation. Control of the speed of the spool traverse provides smoother shifting. Can be externally piloted if desired. Rated capacity is 8 gpm and maximum operating pressure is 2000 psi. Eleven spool modifications are available, including tandem type. Double A Products Co., Manchester, Mich.

For more information—
Circle 29, inside back cover

Variable timer . . .

provides a selected time delay between 0.3 and 10 sec with an accuracy of ± 5%. Timer provides an output energy in excess of 35,000 ergs. Temperature ambients from —70 F to 165 F and accelerations to 100 G have no effect on its operation. Transient circuits are used to achieve the time delay. Developed for use in missile systems and airborne applications, but should be useful in programming devices. Patterson, Moos Div., Universal Winding Co., Inc., 90-28 Van Wyck Expressway, Jaimaica, N. Y.

For more information—
Circle 30, inside back cover

10-gpm variable delivery hydraulic pump . . .

achieves rotational speeds to 4500 rpm, continuous duty. It has a 2.8 hp/lb ratio, usually associated with small, high-speed pumps operating between 8,000 and 10,000 rpm. Delivers over 50 hp (hydraulic) in an envelope 9⅛ x 6¼ in., weighing about 19 lb. At operating speed, pressure differential between full and zero is less than 50 psi with a rapid response rate. Has self-aligning rotating members, low pulsation and oversurge characteristics.

(Continued on page 160)

Will your blueprints *speed*—or stall—the job?

SLOWDOWNS on the job are inevitable when blueprints are hard to read. Worse than that—costly mistakes are only a wrong guess away.

It just doesn't pay to gamble when you can remove this hazard so easily . . . and at trifling cost. Simply ask your printroom, or local blueprinter, to make your prints from Kodagraph Autopositive Paper intermediates *instead of the original drawings.*

How does this assure you consistently legible prints? First, Autopositive intermediates keep their line crispness and density even after hundreds of printings . . . do not smudge, smear, lose graphite. Second, if your drawings are yellowed, soiled, creased, or have weak lines, the use of these photographic intermediates will enable you to produce legible prints from such "unprintable" originals . . . to clean up backgrounds, step up line contrast and density, *without retracing.*

So easy to make Kodagraph Autopositive intermediates—a print-making machine for exposing; standard photographic chemicals for processing; operation under ordinary room light; no negative step! For the full story of the many advantages Kodagraph Autopositive Paper and the other Kodagraph Materials have brought thousands of drafting rooms, just mail coupon.

EASTMAN KODAK COMPANY
Graphic Reproduction Division, Rochester 4, N. Y.

New booklet is jam-packed with valuable tips on saving drafting time, protecting drawings, getting better prints.

Kodagraph Reproduction Materials

MAIL COUPON FOR FREE BOOKLET

15-9

EASTMAN KODAK COMPANY
Graphic Reproduction Division, Rochester 4, N. Y.

Gentlemen: Send me a free copy of your new booklet on Kodagraph Reproduction Materials.

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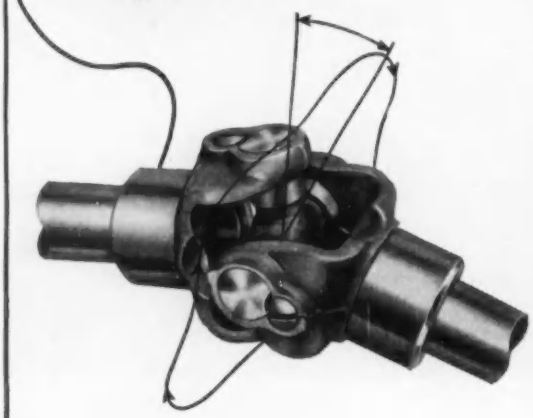
Kodak

THIS ACTION MAY HAVE A

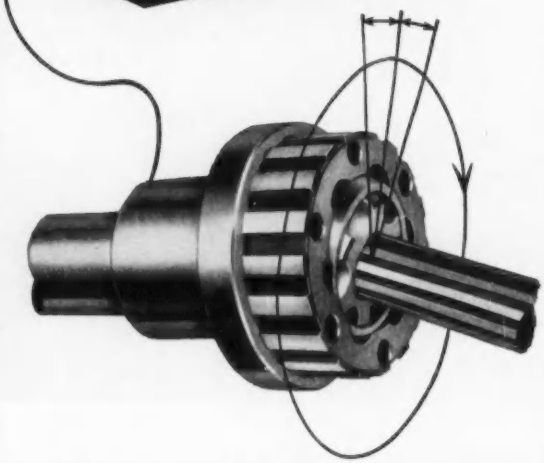
LOWER PRICE



Old-fashioned pin or slipper-type joints speed up, slow down twice during one revolution. This delivers rough "rock and roll" torque which results in greater vibration and wear. They must employ clumsy additional mechanisms to compensate for their unbalanced action at extreme angles.*

THIS ACTION ALWAYS HAS A

LOWER COST



Rzeppa Joints *always* transmit smooth "full power" torque at angles as much as 35°! Ball bearings—located in a plane bisecting the angle between driving and driven members—deliver smooth rotation, eliminating wear and vibration. Constant velocity means longer joint and shaft life, too.*

57A

RZEPPA

SHEPPA

CONSTANT VELOCITY UNIVERSAL JOINTS

The Gear Grinding Machine Company

3939 CHRISTOPHER, DETROIT 11, MICHIGAN

MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES
DETROIT SCREWMATIC 750 SINGLE SPINDLE SCREW MACHINES

*HOW RZEPPA'S CONSTANT VELOCITY SAVES YOU MONEY. If a universal joint operates with less friction it wears longer; if it has a higher capacity it can produce more. Through the principle of constant velocity—shown above—Rzeppa delivers these cost-savings that are impossible with designs of lower price.

Send us a dimensional sketch along with peak horsepower, operating angles and R.P.Ms. Our engineers will assist in making a proper joint recommendation. WRITE FOR LATEST BROCHURE.

Breaking fabrication barriers in new materials with cold forging!

Magnesium, Oxygen-free Copper, Zirconium, High Strength Aluminum Alloys

Most companies and engineering personnel are well acquainted with Hunter Douglas' activities in the field of cold forging aluminum and aluminum alloys. Not so well known are our efforts in the production of magnesium and oxygen-free copper components by the same process. Recently, as the result of a concentrated Hunter Douglas research program, tubular zirconium was successfully cold-forged... an achievement which now opens the door to the fabrication of other rare and costly metals by our cold forging techniques.

The field of cold forging is constantly expanding with many new successes destined for the future.

Where stakes are high and being "first" assures a competitive advantage—in lower cost, better design, greater strength—an original approach to your fabrication problem will pay dividends.

Hunter Douglas cold forging techniques, backed by an unmatched experience in this field, frequently supply the missing key. Many fabrication problems can be solved simultaneously by producing hollow, dense, zero-draft components meeting exact part geometry requirements and difficult performance specifications.

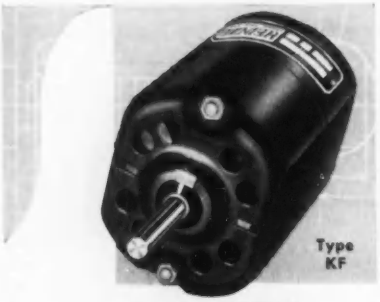
If you have production requirements in any of the metals now being regularly cold forged, we welcome the opportunity of reviewing prints and submitting quotations. Especially important, *if you have an advanced program involving zirconium or other rare metals,* we are in position to devote development facilities to the solution of specific high priority problems.

Among Hunter Douglas' many achievements is the first successful cold forging technique for zirconium ...a metal long believed unresponsive to this process!

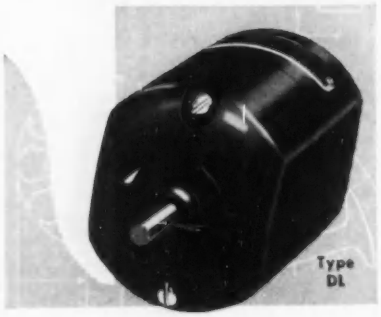
By cold forging, the hard surface oxides, carbides and nitrides normally produced by hot working were completely absent, surface finish was good, and in tubular shapes tolerances on diameters and concentricity were held to a few thousandths... far superior to hot extrusions. With almost complete elimination of machining, metal waste was negligible... an extremely important factor with material costs running as high as $20.00 per pound!

Cold forging of oxygen-free copper is now proving important to the electronics industry and experimental development work is in progress on magnesium and even common metals, such as steel. Out of this extensive research program is coming the vital knowledge for meeting tomorrow's unusual problems. Look to Hunter Douglas for everything new in cold forging!

Hunter Douglas Aluminum
Division of BRIDGEPORT BRASS COMPANY
Dept. PE-9, Riverside, California, Telephone OVerland 3-3030



put HEINZE in your designs



VERSATILITY...IN HEINZE UNIVERSAL MOTORS

Variable speed . . . high starting torque . . . reversibility . . . high output . . . you get them all in Heinze Universal Motors. Horsepower ratings are from 1/15 hp to 1/50 hp, with load speeds of 5000 to 7500 rpm. Normally designed for 115V AC/DC, CW, CCW or reversing. Other voltages are available. Internal or external brushes may be supplied. Type DL has die cast housing. Broad applications include sewing machines, business machines, movie projectors, electric organs, small hand tools.

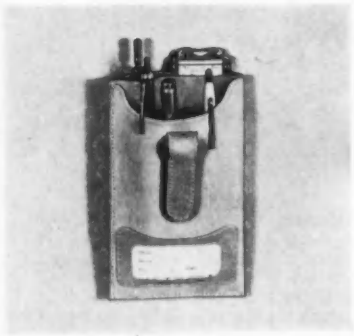
You have a wide choice of models from the comprehensive line of Heinze sub-fractional horsepower motors and blowers. Send us your product and specifications. Heinze Engineers will adapt a motor, at no obligation. Or write for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.

Sub-Fractional Horsepower Motors and Blowers

Suitable for systems requiring capacities to 30 gpm and to 3000 psi. Adaptable for servo applications. Available in prototype quantities. Stratopower Div., New York Air Brake Co., Watertown, N. Y.

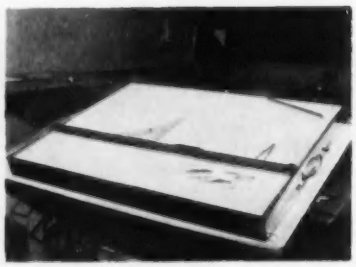
For more information—
Circle 31, inside back cover



Pocket organizer . . .

has three compartments to carry a 6 in. slide rule, plastic rule, and up to six pens and pencils. Spring steel, leather-covered safety clip keeps case in pocket. Case is tan saddle leather. Measures 3¼ x 5¾ in. Costs $3.00, postpaid. Bauer-Lee & Co., 136 E. Montecito Ave., Sierra Madre, Calif.

For more information—
Circle 32, inside back cover



Portable tracing unit . . .

has a built-in straight edge and adjustable back legs to make it a self-contained unit, usable on any desk, table or board. Illuminated area is 35¼ x 47¼ in., with uniform lighting provided by four 30 w fluorescent lamps. Has Plexiglas top and rolled stainless steel frame. Porta Trace, Inc., 342 Clinton St., Binghamton, N. Y.

For more information—
Circle 33, inside back cover

Blueprint paper . . .

combines high contrast with wide latitude in printing speed and requires no change from standard printing or developing techniques. Coating adds stiffness to the paper, yet trimming shears cut easily with-

(Continued on page 165)

BUGGY-WHIP NAMEPLATES on your jet-age products?

Stop losing production line dollars on slow, costly rivet-mounted nameplates that scrape, scratch, become hard to read.

Switch to THINPLATES®, the adhesive backed anodized aluminum foil nameplates!

Thinplates mount in a moment to any surface, bond permanently. Thinplates' anodized surfaces never scratch, scrape or peel, stay bright and legible for the lifetime of aluminum.

Thinplates go anywhere and stay there! For identification, decoration, nomenclature, operating instructions, Thinplates are used on everything from aircraft to skillets.

Don't entrust your product's name to cumbersome rivet mounted nameplates and easily damaged paper decals—use anodized aluminum Thinplates that save time and dollars.

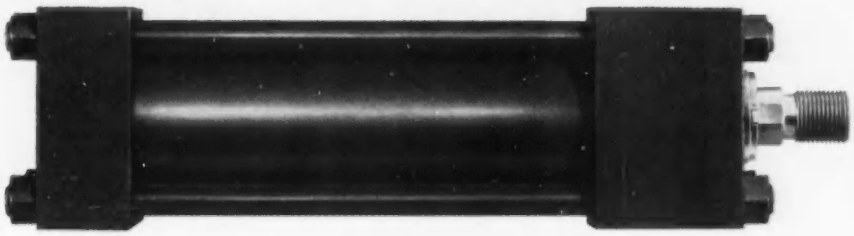
FREE! Send today for samples of Thinplate that will spark your product design and economy ideas. Write on your letterhead to Department PE9.

Users of Thinplate include:
Avco Manufacturing Co.
Bendix Aviation Corp.
Chrysler Corp.
Eastman Kodak Co.
General Electric Co.
General Motors Corp.
Minneapolis-Honeywell Regulator Co.
Radio Corporation of America
Sperry-Rand Corp.
Sunbeam Corp.
Westinghouse Electric Corp.
. . . and many more of the biggest names in American industry!

P **PARK nameplate company, inc.**
34-10 Linden Place, Flushing 54, N. Y

THINPLATE is the Park name for its selective color anodized aluminum foil nameplates in .003" and .005" gauges, with adhesive backing.

Made for the tough buyer



The discriminating engineer is intolerant—intolerant of anything but the very best in his plant and in his product.

For these tough buyers Hannifin cylinders are made. Into these cylinders go original, exclusive features of design, precision manufacture, and the ability to outperform others with the very minimum of maintenance.

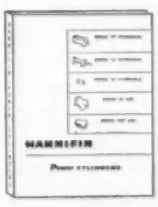
You would expect to pay more for Hannifin cylinders. Actually there is no price premium. We can deliver them to you promptly in the sizes and mounting styles you require.

AIR AND HYDRAULIC

HANNIFIN

POWER CYLINDERS

Write for your copy of this new Hannifin Cylinder File—complete, easy-to-use, easy-to-order-from information on five lines of Hannifin cylinders. Hannifin Corporation, 525 South Wolf Road, Des Plaines, Illinois.



New stop clock designed for accuracy, versatility

Today's product designer, control systems engineer, nuclear physicist, and graphic panel manufacturer have a common need—an instrument capable of measuring elapsed time to a hundredth of a second, with an accuracy better than 0.02 of 1%.

Wide field—wide requirements

But there the sameness ends—the nuclear physicist needs a hermetically sealed device for remote control; the product designer requires load switches and local pushbutton reset; the graphic panel man wants smart appearance. The lab technician wants a portable model. The military asks for the smallest unit consistent with reliable readings, while the sports event timekeeper must have a large dial.

How can you meet these diverse requirements? Well, here's the answer to that question—a product of Cramer's experience and knowledge of precision timing.

Accuracy for everybody

You select a small, powerful and inherently accurate drive motor, add a 110-tooth positive clutch and apply it on the high-speed shaft. Back it up with a potent relay. When the signal comes, the unit responds instantly, and we have *accuracy*.

All-electric operation for flexibility

Add heart cams on the mainshaft and a rugged solenoid to belt them home within 1/10 second after the reset switch is operated. Now we have *electrical reset*, either remote or local.

For *versatility*, provide for load switches with cams on fast or slow pointer shafts. Cut and set at the factory, cams will offer a variable number (and duration) of pulses per second or minute, or with load switches wired in series, the unit can be used as a highly precise time delay relay or interval timer.

Commercial or Mil-Spec housings

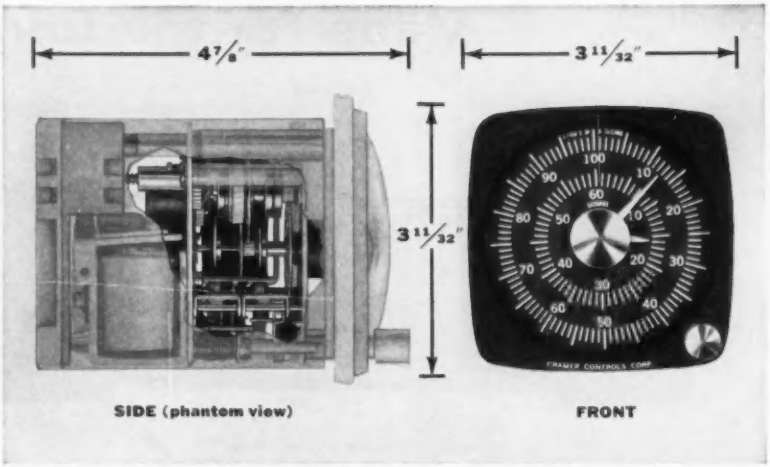
Now let's enclose the mechanism. Commercial housing is dust-tight and has a 12-place terminal block. Also developed: a militarized model to withstand high vibration, shock and severe environments. A deep-drawn solder-sealed enclosure with 14-pin glass-beaded header, evacuated and hermetically sealed will do it.

Dials, pointers—Loewy styled

What's left? The business end of things—dial and pointers. Let's tackle this for readability, and at the same time, shoot for eye-appeal. This time we'll go to the *styling* experts — famous industrial designers, Raymond Loewy Associates. They come up with the last word in human-engineered dial-pointer combination for fast, exact readings. Frame it with a pleasing bezel that can be finished to match or harmonize with your panels.

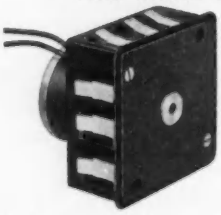
Now it looks like the precise instrument that it is—the new Cramer Type 691 Time Totalizer. Bulletin PB-691 tells more about it. Write for your copy today. The Cramer Controls Corp., Box 7, Centerbrook, Conn.

P.S. We've got the six-inch dial version and the portable model, too. 7.20

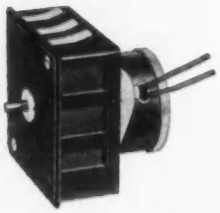


NEW time totalizer. Type 691 features instantaneous electrical reset, accuracy within 0.02 of 1%. Standard ranges: 60 seconds in 1/100 sec., 60 minutes in 1/100 min., and 60 minutes in seconds. Factory-set cam-operated load switches (rated at 5A, 250 vac, resistive) can be supplied. Available for standard voltages at 50, 60 cps; for 400 cps with d-c clutch; and for d-c voltages. Mechanical and electrical life in excess of 1-million operations.

TWO MORE NEW CRAMER PRODUCTS



NEW cycling timer. Type 571, ideal for "cycling" electrical equipment such as appliances, vending machines, advertising displays, at lowest possible cost. 1 to 4 poles. Speeds from 1 rpm to 1 revolution in 8 days with 30-amp contacts. Faster speeds with lighter contacts on special order.



NEW interval timer. Type 271, for built-in applications. Provides an economical way of timing appliances, photo equipment, ovens, etc., for manually preset interval. 1 or 2 poles. Time ranges from 45 seconds to 6 days with 30-amp contacts. Normally furnished without knob or dial.

TALK IT OVER WITH

CRAMER CONTROLS CORPORATION

CUT

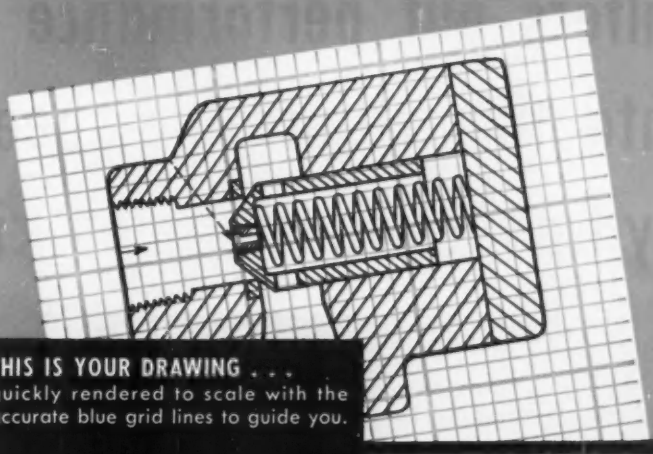
YOUR DRAFTING TIME AND COSTS WITH CLEARPRINT "FADE-OUT" PAPER

Leading engineers and designers report that Clearprint Fade-Out Paper speeds up their drafting 10 to 15% . . . cuts their costs proportionately. And Fade-Out Paper gives them prints which are sharper and easier to read, because grid lines do not reproduce.

Clearprint's perfect working surface invites pencil and pen — lines are sharp and clean. It withstands repeated erasures, too, without the slightest ghosting.

See how Clearprint Fade-Out Paper can solve *your* drafting problems. Order a trial roll now, and apply it to your various drawing needs.

Available with grids ruled 4x4, 5x5, 8x8 and 10x10 lines to the inch.



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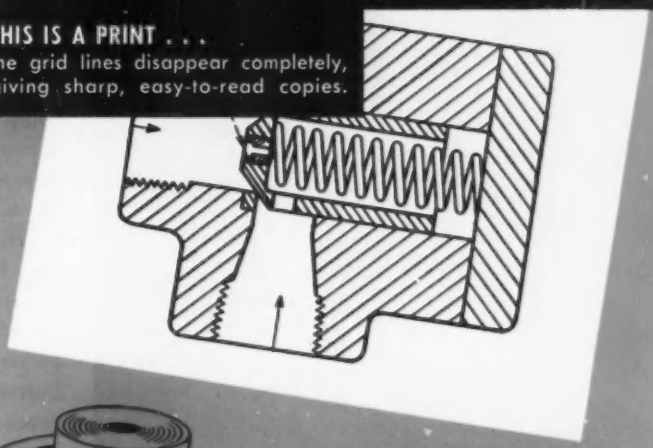

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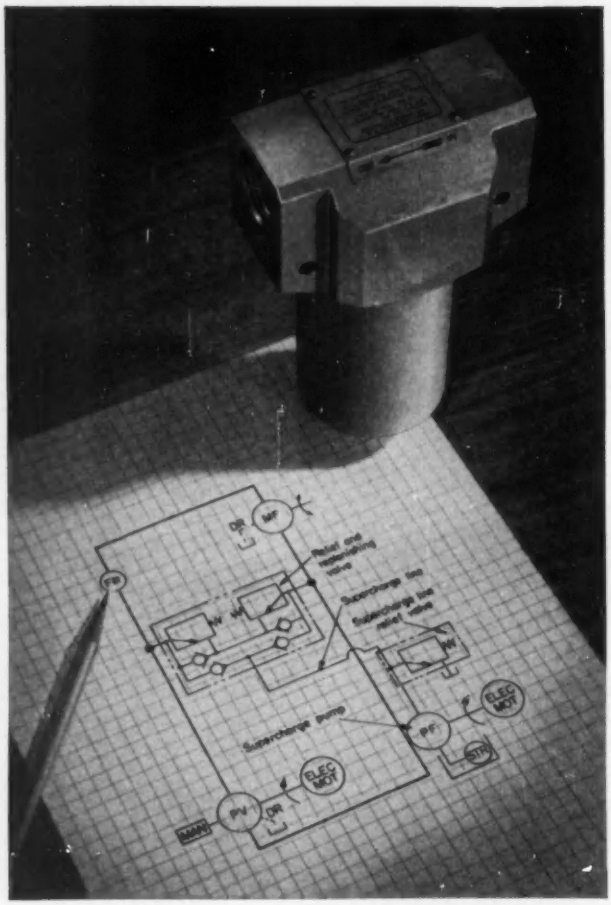
Filters put performance into this adjustable-speed hydraulic transmission circuit



For applications requiring any combination of torque and horsepower characteristics, an adjustable-speed hydraulic transmission consisting of a variable-delivery pump and variable-displacement fluid motor is generally used. In a reversing adjustable-speed hydraulic transmission circuit, either pump line may be the intake side. This type of transmission can be used to advantage in applications requiring a wide speed range. Over-all efficiency for this type of hydraulic transmission is approximately 85 per cent for all output speeds greater than 30 per cent of maximum.

In development of variable-speed transmission circuits, the rules and factors governing the design of hydraulic circuits in general apply. Protection of hydraulic fluid from contamination is essential for dependable performance of the circuit. And Purolator filters provide the most effective protection available today. The unit shown (PR-412-8) is used in many circuits like that above. It is part of a series offering a range in nominal rated capacity from ½ to 12 gallons per minute. The case can be unscrewed and removed for replacement of the element without disturbance to connections. To improve your hydraulic system, get precisely the filter you need by contacting Purolator.

THIS CIRCUIT incorporates a supercharge pump and a reversible replenishing system. Supercharging increases capacity of the main pump by maintaining pressure at the pump inlet and removing the possibility of cavitation at high flow rates. The supercharge pump has its own relief valve which limits inlet pressure to the main pump to approximately 150 psi. The relief and replenishing valve is a single unit which because of the arrangement of the check valves admits fluid to the system on the low-pressure side of the main pump but does not permit fluid pressure to be lost from the high-pressure side despite flow reversal.

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Rahway, New Jersey and Toronto, Ontario, Canada

out snagging or tearing. Ink and water colors have less tendency to feather. Blueprint eradicators work satisfactorily. Blue-line prints can be made without bleeding. In the field, the paper is said to have diminished tendency to fade in direct sunlight. Keuffel & Esser Co., 260 Madison Ave., New York 16, N. Y.

For more information—
Circle 34, inside back cover

Illuminated portable tracing board . . .

can be used by design engineers, technicians and draftsmen for a wide variety of photographic, reproduction, and drafting operations. Thin enough to be slipped under a string-type parallel rule on a standard size drafting board. Dimensions permit use under standard straight edge or drafting machine. Rubber feet hold it in position, even at an acute angle. Has opal Plexiglas flush top. Fluorescent lighting prevents overheating. Available with tracing surfaces from 10 x 17¼ in. to 23¾ x 35¼ x 36¼ in. Components are U/L-approved. Ozalid Div., General Aniline and Film Corp., 6 Corliss Lane, Johnson City, N. Y.

For more information—
Circle 35, inside back cover

Calculator . . .

gives direct reading in lb/ft or lb/sq ft via four movable dials, for over 1000 steel items, including bars, pipe and sheets. A 10-in. circular slide rule is provided on reverse side. The finder takes the place of reference books and charts usually required in steel purchasing and estimating. It does not use the scale system. Weights are given in numbers to three and four decimal places where required. Made of paper board, printed, die-cut and assembled. Price is $2.50. Alcott Calculator Co., P.O. Box 4604, Ft. Lauderdale, Fla.

For more information—
Circle 36, inside back cover

KEY SOURCE FOR SMALL MOTORS

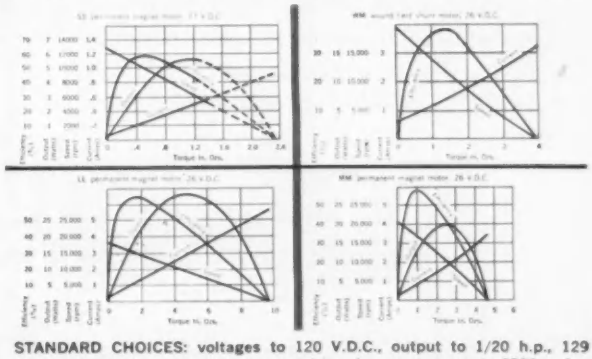
Globe Industries should be your prime source for small, peak performance A.C. and D.C. motors for fundamental reasons. For instance, the four D.C. motors shown are just a beginning —not only can you have them in countless variations, but you can add scores of standard spur or planetary gear ratios. Also, a wide variety of governors, clutches, brakes and filters are available promptly to meet any need you have. All these variables are combined by Globe to give you a motor which outperforms any other motor of comparable size.

An interchangeable standard part inventory, coupled with precision production techniques to match engineering efficiency are specific reasons why you can obtain quality custom built prototypes in 2 to 4 weeks. These same methods shorten lead time on Globe actuators, timers, rate gyros, blowers, servos.

Ask the largest D.C. miniature motor manufacturer first.

Send for your copy of the Globe D.C. motor catalog now.

GLOBE INDUSTRIES, INC., 1784 Stanley Avenue, Dayton 4, Ohio, HE 3741



STANDARD CHOICES: voltages to 120 V.D.C., output to 1/20 h.p., 129 spur and planetary gear ratios, geared break away torques to 2500 oz.in., many varieties of governors, clutches, brakes, and filters are available. The graphs appearing above illustrate typical performances.

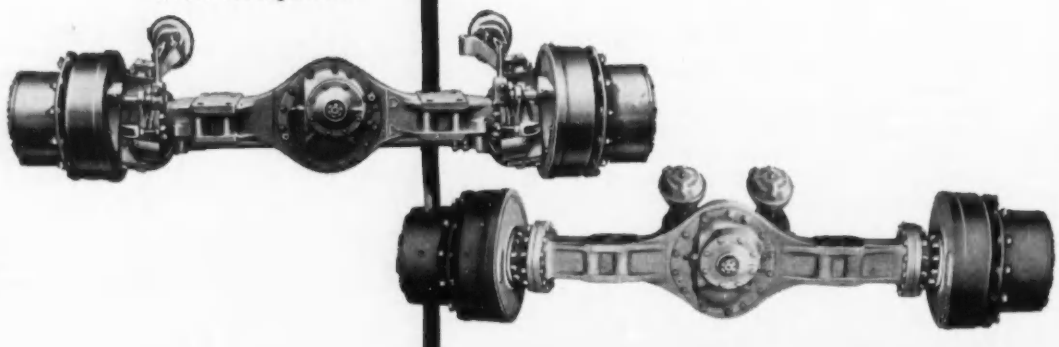
To designers and builders of heavy-duty off-highway vehicles...

TIMKEN-DETROIT® OFFERS today's broadest range of planetary axles

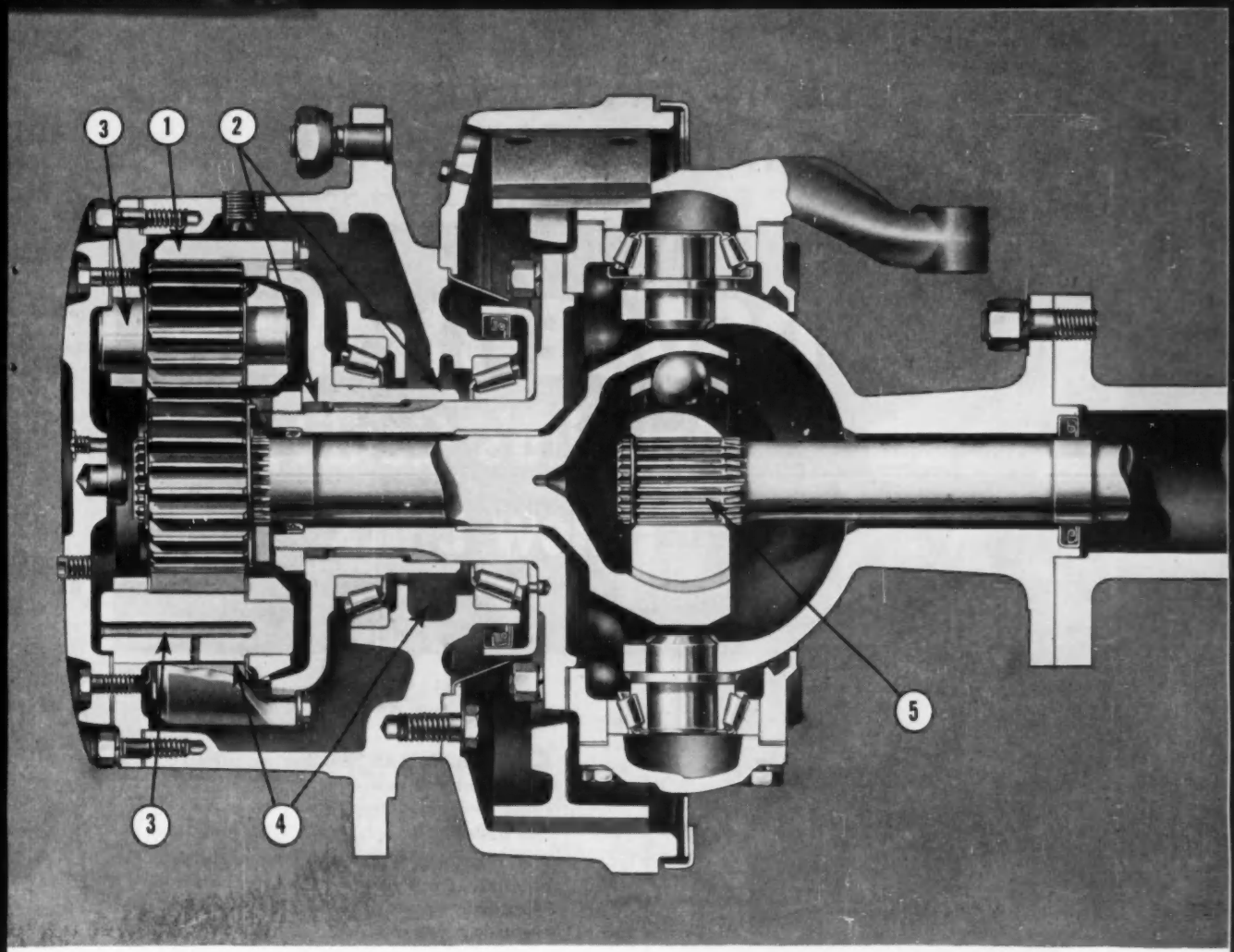
Timken-Detroit pioneered planetary axles for heavy-duty applications. And today, the Timken-Detroit family of advanced design axles includes a complete range of new planetary heavy-duty axles . . . with a steering axle operationally matched to each rigid axle in the line. They are backed by 50 years of design, engineering and manufacturing leadership . . . plus constant field testing, laboratory research and development.

Only New Timken-Detroit Full Planetary Design Brings You All These Features for Extra-Long Life, and Extra Dependability!

1 Floating Ring Gear and hub are two separate pieces. Combined with floating sun gear, this feature assures equal distribution of stresses to all planetary gears, gives longer, trouble-free gear life.



WORLD'S LARGEST MANUFACTURER OF AXLES



2 Concentrically Ground Ring Gear Hub and Spindle Mounting Surfaces assure perfect alignment—plus freedom from bending forces on the hub and spindle splines. Splines absorb only torsional stresses from the ring gear.

3 Special Forged Bronze Planet Pinion Pins of premium alloy bronze for longer, trouble-free operation. Rifle drilled lubrication channels and machined lubrication flats assure full time lubrication. Pin is locked in place by cover to prevent rotation. This results in longer pin life.

4 Full-Flow Oil Lubrication of Planetary Outer End assures constant flow of lubricants to wheel bearings and all planet gears. When vehicle is not in motion oil is retained in cast reservoirs to provide ample initial lubrication.

5 New Axle Spline Design with a greater root diameter and more splines per shaft decreases individual spline load for longer, more dependable operating life. Splines at differential are enveloped by side gears to give uniform stress distribution.

High-Traction® Differential automatically compensates for the loss of traction of one driving wheel by transmitting additional power to the other driving wheel having traction. This unit operates equally well in either forward or reverse. (Available as optional equipment.)

High Degree of Parts Interchangeability between both rigid and steering axles in the same series. This means smaller parts inventory, low maintenance costs and more productive work time with Timken-Detroit Planetary equipped vehicles.

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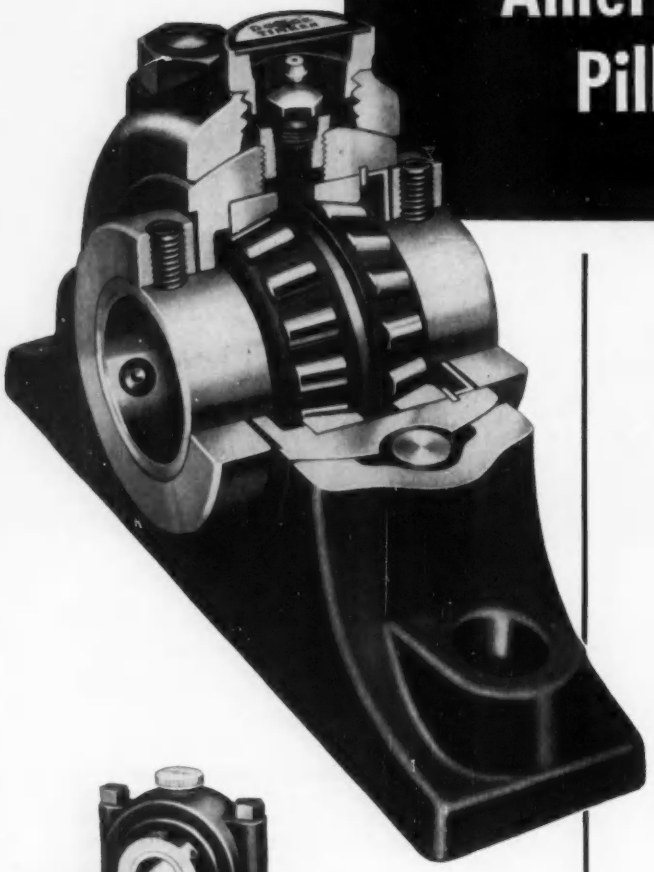

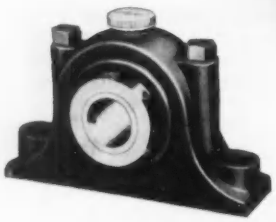

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Where service conditions are toughest Dodge-Timken Bearings prove their quality decisively. For superior performance, dependability and long life they have won their reputation throughout industry as America's quality pillow blocks.

To meet varying service requirements Dodge-Timken Pillow Blocks are available in five types—the type E . . Double Interlock (illustrated) . . Type C . . Special Duty . . . and All-Steel. Available in a range of shaft sizes from 1-3/16" to 10".

Call your Transmissioneer; or write for Bulletin A638 giving load ratings, dimensions and other data on Dodge-Timken Roller Bearings.

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1200 Union Street, Mishawaka, Indiana

DODGE
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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 177.

HEAT RESISTANT CASTINGS—Data Sheet File, 30 pp. Complete technical data marking the completion of a 10-yr compilation and research project. Lists room and elevated temperature properties of each of the cast heat resistant alloy grades and specific property data. In addition, the sheets give a concise discussion of applications, design and fabricating characteristics of each alloy. Metallurgical structure and characteristics of each alloy are also completely described. Alloy Casting Institute, 286 Old Country Rd., Mineola, N. Y.

Circle 37, inside back cover

OILLESS BEARINGS—Catalog 240, 24 pp. Includes specifications, lists sizes and operating characteristics of standard conveyor roll bearings as well as self-sealing, free-draining and conical bearings for use on belt, live roller, gravity roller and special conveyors. Arguto Oilless Bearing Co., 149 W. Berkeley St., Philadelphia 44, Pa.

Circle 38, inside back cover

TIME SAVING TIPS FOR THE DRAFTSMAN AND ENGINEER—Booklet, 34 pp. 59 shortcuts to speed drafting and computation work. Frederick Post Co., 3650 N. Avondale Ave., Chicago 18, Ill.

Circle 39, inside back cover

HEAT EXCHANGERS—Booklet, 20 pp. Provides a design and cost comparison between plain condenser tubes and shell and tube exchangers over the range of more common applications. With performance curves, charts and graphs. Specifications and application data are included. Wolverine Tube, Div. of Calumet & Hecla, Inc., Guardian Towers, Guardian Bldg., Detroit 26, Mich.

Circle 40, inside back cover

NICKEL-CHROMIUM ALLOY—Catalog M-57A, 20 pp. Metallurgical data and design information on Chromel-A. Includes prices and specification on the alloy in resistance wire, ribbon and furnace strip form. Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.

Circle 41, inside back cover

SURFACE ROUGHNESS, WAVINESS AND LAY STANDARDS—Booket, 24 pp. Standard defines geometric irregularities of solid material and physical specimens for gaging roughness. It is broken down into a classification of surface characteristics, designation of surface characteristics, stylus type measurements, precision reference specimens and roughness comparison specimens, with four appendices containing examples and supplementary information. Published recently by ASME. Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle 42, inside back cover

DIGITAL VOLTMETER APPLICATION AND DATA—Booklet, 28 pp. Describes line of digital voltmeters; digital ohmmeters; a-c, d-c converters, and data logging systems. Illustrated with charts, diagrams and photos. Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif.

Circle 43, inside back cover

MICA SELECTOR—Bulletin 2661, 2 pp. Size and quality of natural mica needed for fabricated parts can be determined by placing the part or sketch on the full-size grading chart provided in the bulletin. Also, information on mica characteristics, sheet thickness and tolerances available. Ford Radio & Mica Corp., 536-63rd St., Brooklyn 20, N. Y.

Circle 44, inside back cover

SUBMINIATURE CONNECTORS—Brochure, 12 pp. Specifications, dimensional drawings, illustrations and general information are included. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 45, inside back cover

COILED CORDS—Catalog, 16 pp. Describes characteristics and uses of coiled cords; wire types and constructions available; terminations that can be used. Engineering data and dimensional drawings are shown for rubber and thermoplastic plugs and connectors that can be molded onto the cords. Cords Limited Div., Essex Wire Corp., 121 Dodge Ave., DeKalb, Ill.

Circle 46, inside back cover

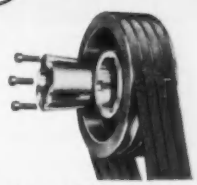
SILICONE MOLDING COMPOUNDS—Brochure 7-603, 4 pp. Discusses physical and dielectric properties at high temperatures, with charts, graphs and field examples. Dow Corning Corp., Midland, Mich.

Circle 47, inside back cover

STATIC SEALS—Catalog, 22 pp. Describes and illustrates many of the standard

(Continued on page 170)

DODGE PRODUCTS you should know



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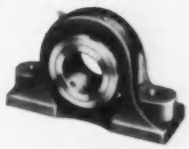

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- Rolling Bearings—SC, SCM and Dodge-Timken. Bulletin A-638

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TIMER RELAY
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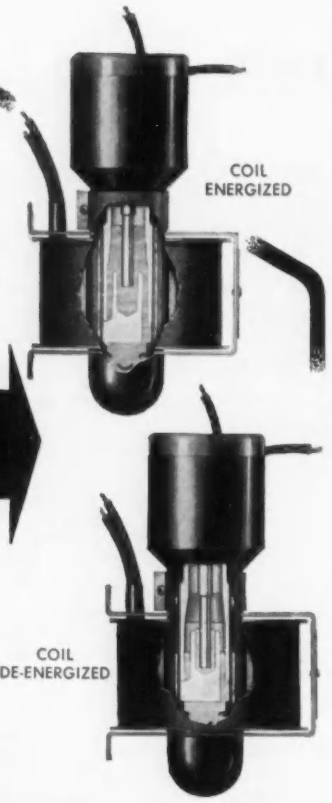

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This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.

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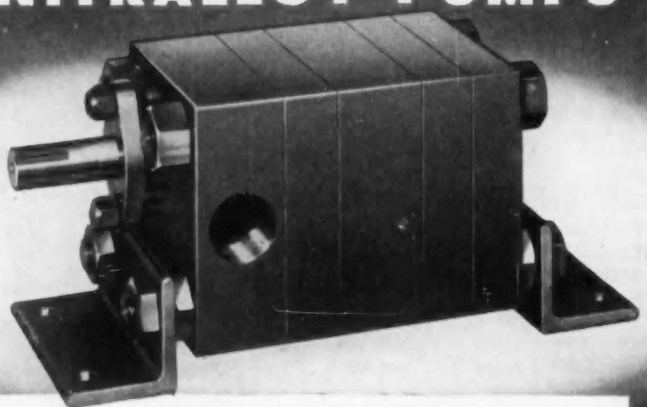

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seals, as well as some special seals. Gives dimensional and property data about each Illustrated with dimensional and cutaway drawings. Franklin C. Wolfe Co., Div. of Parker Appliance Co., 10567 Jefferson Blvd., Culver City, Calif.

Circle 48, inside back cover

PANEL METERS—Catalog, 16 pp. Dimensional details and performance specifications for round and square panel instruments. Also, data on custom meters. Illustrated with photos and diagrams. Waters Mfg., Inc., Boston Post Rd., Wayland, Mass.

Circle 49, inside back cover

INTERMEDIATE WHITEPRINT MATERIALS—Bulletin, 4 pp. Suggests how these materials enable design engineers, draftsmen and technicians to cut drafting time, speed design change, safeguard originals and make complete prints. Gives catalog listings and descriptions of intermediate materials. Ozalid Div., General Aniline and Film Corp., 5 Corliss Lane, Johnson City, N. Y.

Circle 50, inside back cover

CONTROL UNITS FOR MAGNETIC CHUCKS—Brochure, 6 pp. describes line of control units for 7 sec demagnetization of low voltage magnetic chucks. Physical dimensions, ratings, and specifications on all of the 21 models are summarized in a table. Application and construction data is included. Illustrated with photos and operational diagrams. Sundstrand Machine Tool Co., 1020 9th St., Rockford, Ill.

Circle 51, inside back cover

HEAVY DUTY TERMINAL BLOCKS—Catalog SB-160, 4 pp. Complete line is listed and illustrated with series number and specifications. Marathon Electric Mfg. Corp., Wausau, Wis.

Circle 52, inside back cover

STAINLESS STEEL FASTENERS—Catalog, 8 pp. Condensed guide to fasteners normally carried in stock. 37 types of standard fasteners are illustrated. Data on sizes, threads, head and point styles and grades of stainless steel is included. All-metal Screw Products Co., Inc., 821 Stewart Ave., Garden City, N. Y.

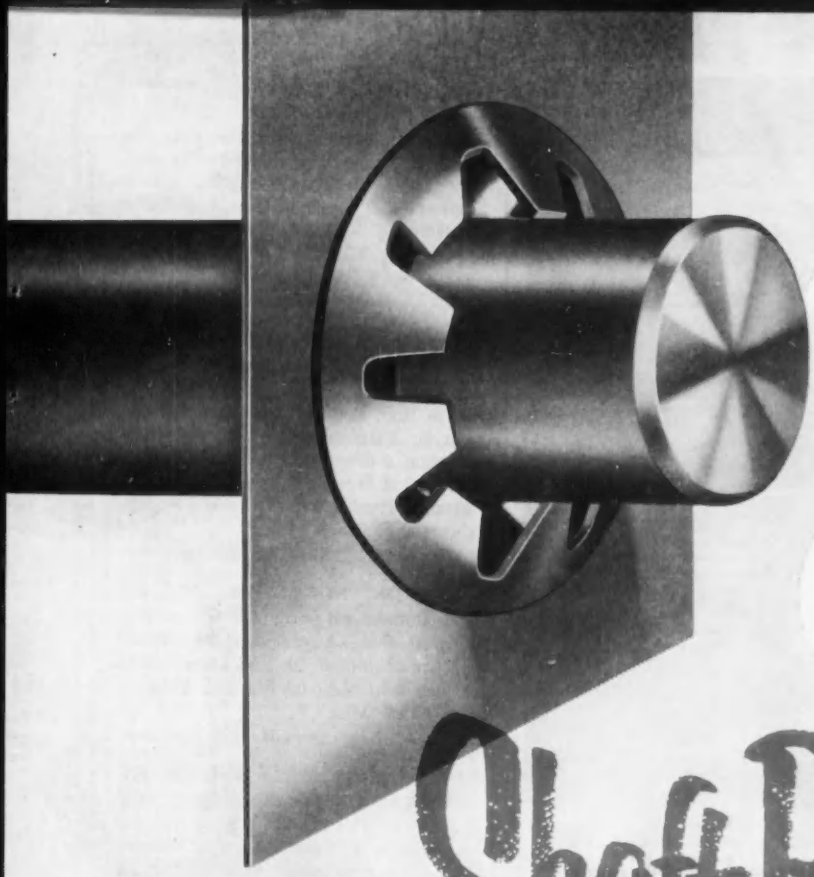
Circle 53, inside back cover

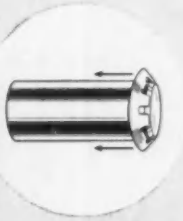
GLASS FIBER TUBING—Data Sheet, 2 pp. Outlines characteristics, advantages, limitations and uses of tubular glass fiber parts. Pacifica Laminates, 1919 Placentia Ave., Costa Mesa, Calif.

Circle 54, inside back cover

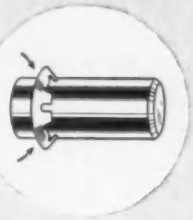
WELDED STEEL TUBING TOLERANCES—Booklet, 14 pp. Pocket-sized reference containing the most recent information on commercial tolerances for

(Continued on page 172)





Pilot teeth guide fastener on for easy hand starting.



Hardened spring steel teeth bite in, resist dislodging force.

for positive Shaft Retention

FASTEX® SPRINGRIP FASTENERS

Simplify assembly, save costs! Springrip Fasteners are simple to apply to rods and studs . . . assure exceptional strength without special preparation . . . no costly threading or drilling required. Standard Springrip Fasteners with pilot teeth now in stock and available for immediate delivery. Full details on all cost-saving Springrip Fasteners and other Fastex Shaft Retention Fasteners are found in new Fastex Catalog No. AF-9. This important booklet contains complete technical data, dimensions and application suggestions. Write for your catalog today!

Other *FASTEX*® Shaft Retention Fasteners

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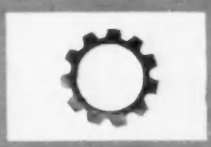
Made of non-aging, chemical resistant vinyl . . . act as positive holding shoulder.

FASTEX® Push-On Fasteners
Slip over studs, shafts, rods or bolts . . . hold tight under pressure or vibration.

FASTEX® "C" Ring Retainers
The fast, simple method for retention or spacing on rods or shafts . . .



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For use in tubes or bored holes . . . provide spring lock for positive retention.

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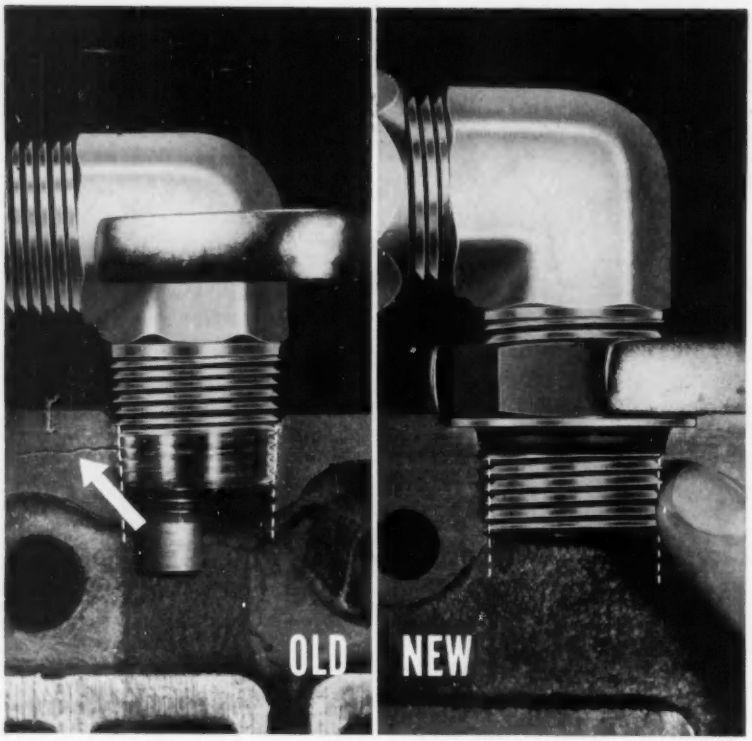

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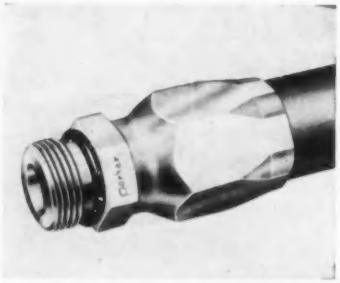
Forget about danger of cracking or distorting valve bodies by overtightening the fittings. Forget about messy pipe "dope." Forget about leakage problems resulting from tapered pipe threads in high-pressure hydraulic systems.

Eliminate these problems. Use Parker O-ring seal straight-thread fittings (which conform with the SAE Standard for Hydraulic Tube Fittings) for leakproof, trouble-free connections. Available on both *Triple-lok* (see Catalog 4310) and *Ferulok* (Catalog 4320).

Ask your Parker Distributor today for catalogs or write to —



New, Broader Line of *Hoze-lok* fittings for medium- and high-pressure hydraulic service. No skiving of hose cover. Easier make-up saves time and money. Longer performance, greater re-usability. Catalogs 4433 and 4434.

TUBE AND HOSE FITTINGS DIVISION, Section 435-CC
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Hydraulic and fluid system components

Catalogs and Bulletins.....continued

welded steel tubing and other data. Includes tolerance charts for cold rolled steel, hot rolled steel, cut lengths, rounds, squares and rectangulars and propeller shaft tubing. Revere Copper & Brass, Inc., Rome Mfg. Co. Div., P. O. Box 111, Rome, N. Y.

Circle 55, inside back cover

MINIATURE SELF-LOCKING NUTS—Bulletin, 4 pp. Describes self-locking nuts and clinch nuts ranging from No. 0 to 4 dia in steel, stainless steel, brass and aluminum. Diagrams and photos show construction and application details. Specifications and sizes are given in tabular form. Standard Pressed Steel Co., Box 545, Jenkintown, Pa.

Circle 56, inside back cover

HEXAGON NUTS—Catalog, 24 pp. Specifications and prices of sizes from ¼ to 3 in. are given. A guide chart for calculating wrench torques for steel hexagon nuts is included. National Machine Products Co., Utica, Mich.

Circle 57, inside back cover

STAINLESS STEEL, HEX-SOCKET SCREWS—Bulletin G-22, 16 pp. Presents characteristics of the three major types of stainless steels, together with advantages in various applications. One section is devoted to special metal finishes and treatments available on the firm's stainless steel hex-socket screws. Standard sizes of Allen stainless steel hex-socket screws are listed in tabular form, as are recommended tightening torques. Allen Mfg. Co., Hartford 2, Conn.

Circle 58, inside back cover

ELECTRONIC SWITCH CONTROLS—Catalog Z-10, 25 pp. Describes and illustrates standard basic switch controls for electronic, radio, appliance, small motor and military applications. Specifications are given for sizes, electrical ratings, circuits and common features. Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn.

Circle 59, inside back cover

VACUUM IMPREGNATION — Data sheet, 6 pp. Procedures for batch and internal pressure impregnation, including simultaneous bonding of dissimilar materials, are outlined and diagrammed. Applications are listed. Tabular data on physical and electrical properties is included. Western Sealant Co., 9999 W. Jefferson Blvd., Culver City, Calif.

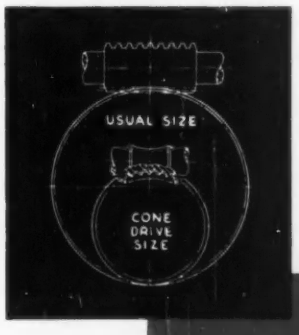
Circle 60, inside back cover

PVC PIPE FITTINGS, FLANGES AND VALVES—Booklet, 24 pp. Technical data and installation information on PVC pipe is supplemented with pressure-temperature charts, chemical resistance tables, support

(Continued on page 177)

if you're looking for

concentrated power



. . . CONE-DRIVE gearing has no equal.

You can pass an amazing amount of power through a set of Cone-Drive gears.

Want to cut product size? Cone-Drive will give you a more compact gear train with reserve load capacity.

Want to boost power output and hold size? That's easy with Cone-Drive gears. They'll carry two, three, and four times the load of cylindrical worm gearing.

Why? In Cone-Drive gears, the load isn't concentrated on a small area per tooth or on just one or two teeth at a time. Cone-Drive's exclusive double-enveloping principle distributes the load over a lot of teeth and over more area on each tooth.

It cuts the unit loading the same way a pair of snowshoes supports a heavy man.

Ask for Bulletin CD-400 for complete details.

CONE-DRIVE GEARS *Division Michigan Tool Company*

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

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You can make design changes simply . . .

and save hours of drafting time . . . with Ozalid's family of intermediate materials

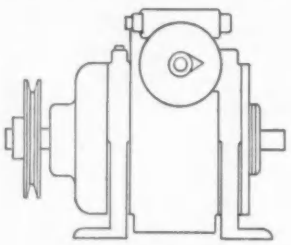
Once . . . just once . . . you run your original drawing through your Ozalid machine with a piece of Ozalid intermediate material. Then file away your drawing. Your Ozalid intermediate copy becomes a duplicate original—all set to give you important benefits.

Take design changes, for instance. With an Ozalid intermediate print, there's no need to trace or redraw the original design. Changes are as easy as 1-2-3 . . . just see below!

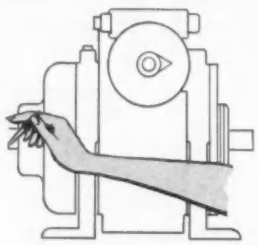
Not only are Ozalid intermediate prints exact copies of your original—they can be *better* than the original. Faded or weak areas are intensified.

There's an Ozalid intermediate material for every drafting room need: film, translucent paper, and cloth.

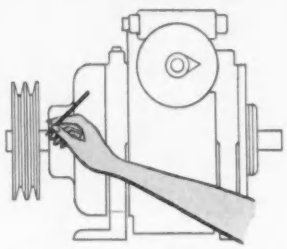
See for yourself how quick and easy you can make design changes with Ozalid intermediates. Contact your local Ozalid man—his name is in the phone book—or write for free folder. Write to Ozalid, Dept. O-9, Johnson City, N. Y. In Canada: Hughes Owens Co., Ltd., Montreal.



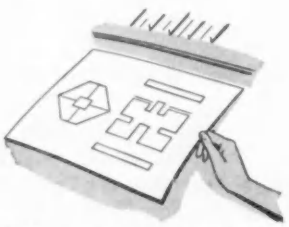
1. This is an Ozalid intermediate (translucent) print of the original drawing.



2. Draftsman eradicates obsolete lines with Ozalid Corrector Fluid.

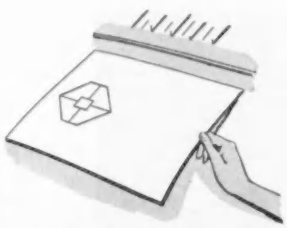


3. New design is drawn in. Prints can now be run from this intermediate "master."



1. Expose original drawing in the usual manner on Ozalid intermediate paper, cloth, or foil. But do not develop!

2. Cover all printed yellow lines which are to be retained on the intermediate with a mask of black opaque paper—re-expose in Ozalid machine. The light will remove all obsolete details left uncovered.



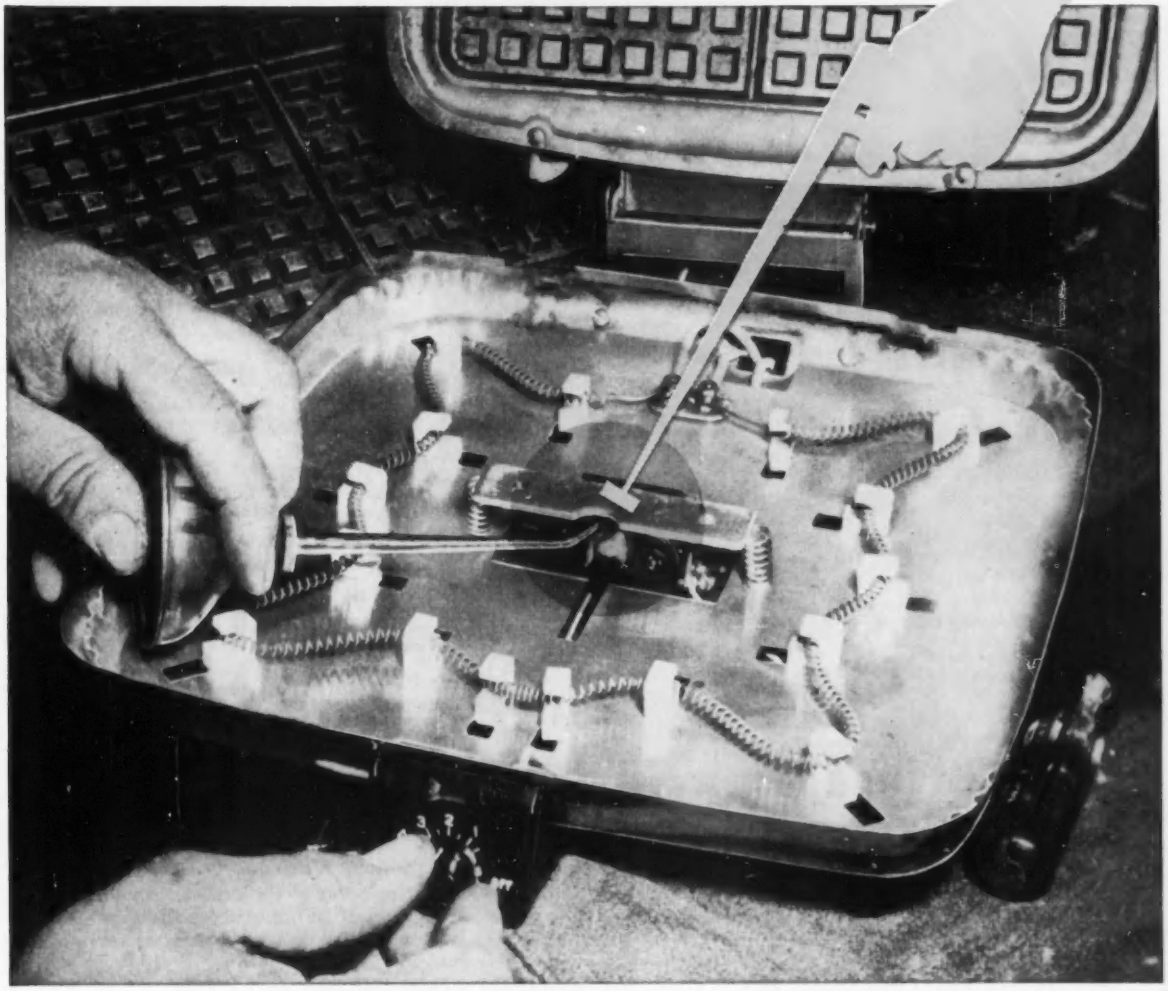
3. Develop the intermediate...and you have a clear, up-to-date "framework" to which you add the new design. Use this intermediate master to produce prints.

OZALID®

Products for Design

A Division of General Aniline & Film Corporation
In Canada: Hughes Owens Company, Ltd., Montreal

A Touch here does so much



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A touch of 'dag'® Colloidal Graphite gives lifetime lubrication to parts operating next to red-hot elements in pop-up toasters and other appliances. It does the same for planetary gears exposed to 1500° F. in high-intensity searchlights.

Where life performance must be built into inaccessible mechanisms, 'dag' dispersions form thin, protective films capable of withstanding temperature extremes and other severe conditions. Your Acheson Service Engineer can discuss the application of 'dag' dispersions related to the life performance of your design. Talk with him soon, and write for Bulletin 423 containing information on design applications for 'dag' dispersions. Address Dept. PE-9.

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ACHESON COLLOIDS COMPANY

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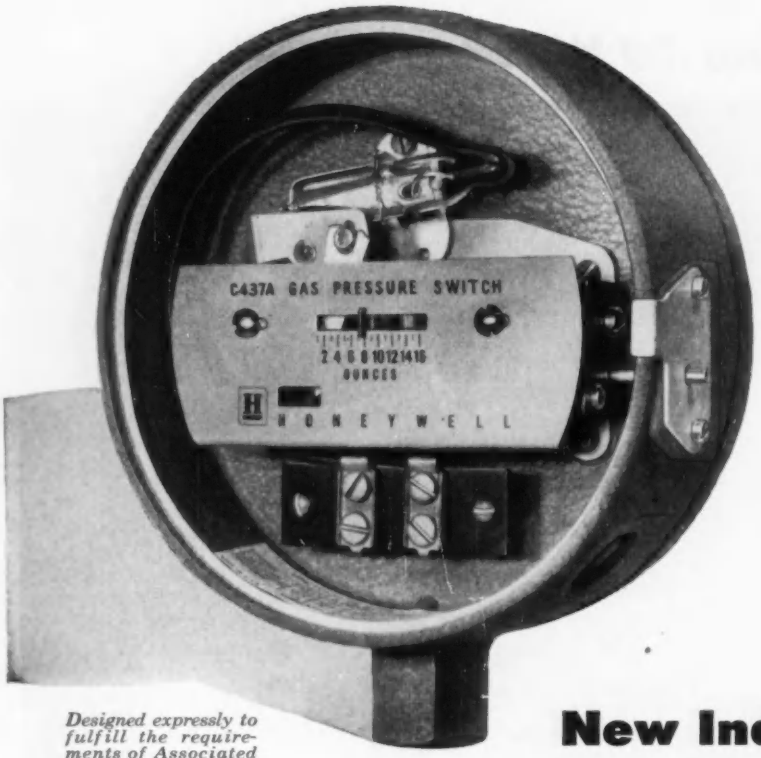


Designed expressly to fulfill the requirements of Associated Factory Mutual.

New Industrial Gas Pressure Switch offers 4 exclusive safety features

USE this new Honeywell C437A Industrial Pressure Switch as a safety cutoff on multiple burner gas installations . . . as a pressure controller for hazardous gases . . . or as a differential controller for air or non-hazardous gases. It's simply designed, yet provides complete protection.

The C437A Industrial Gas Pressure Switch has these exclusive safety features:

1. Sealed Pressure Chamber—Should the diaphragm rupture from over pressure or any other cause, gas can't escape into the switch compartment or to the atmosphere. The pressure chamber is fitted with a pipe tap to permit venting to the stack.

2. Protected Settings—All adjustments are inside the case for protection against careless or accidental manipulation. A metal plate on the side of the case must be removed before changes in adjustment can be made.

3. Ever-Visible Switch Position and Control Settings—The entire cover of the pressure switch is a window. Position of the mercury switch and adjustment of the control settings can be determined at a glance.

4. Lockout Mechanism—An optional safety feature, when manual resetting is desired. The lockout mechanism prevents the switch from remaking contact after pressure has once dropped below the setpoint . . . even though pressure returns to normal. The lockout release button is the only adjustment that can be manipulated without removal of the protecting metal plate.

For complete information, call the nearest Honeywell office. A Honeywell sales engineer is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:**

Send for Specification S1011-1 Honeywell Gas Pressure Switch C437A

MINNEAPOLIS **Honeywell**
BROWN INSTRUMENTS
First in Controls

spacing formulas and lists of industrial organizations using PVC piping. Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky.

Circle 61, inside back cover

TRANSMISSION PRODUCTS—Catalog 914, 88 pp. Descriptive information with drawings and dimensional tables covering a variety of shaft collars, couplings, clutches, pillow blocks, take-ups, wheel hubs, gears, holdbacks, chains and sprocket wheels. Jeffrey Mfg. Co., Columbus 16, Ohio.

Circle 62, inside back cover

CENTRIFUGAL CASTINGS—Catalog 200, 8 pp. Information on custom-made castings in more than 70 alloys, in sizes ranging from 7 to 54 in. OD. Sandusky Foundry & Machine Co., Sandusky, Ohio.

Circle 63, inside back cover

PNEUMATIC FRICTION CLUTCH AND BRAKE—Brochure 37-A, 4 pp. Explains the features of the single disk press clutch and the Type K clutch and brake. A cutaway illustration shows inner workings of the clutch. E. W. Bliss Co., Canton, Ohio.

Circle 64, inside back cover

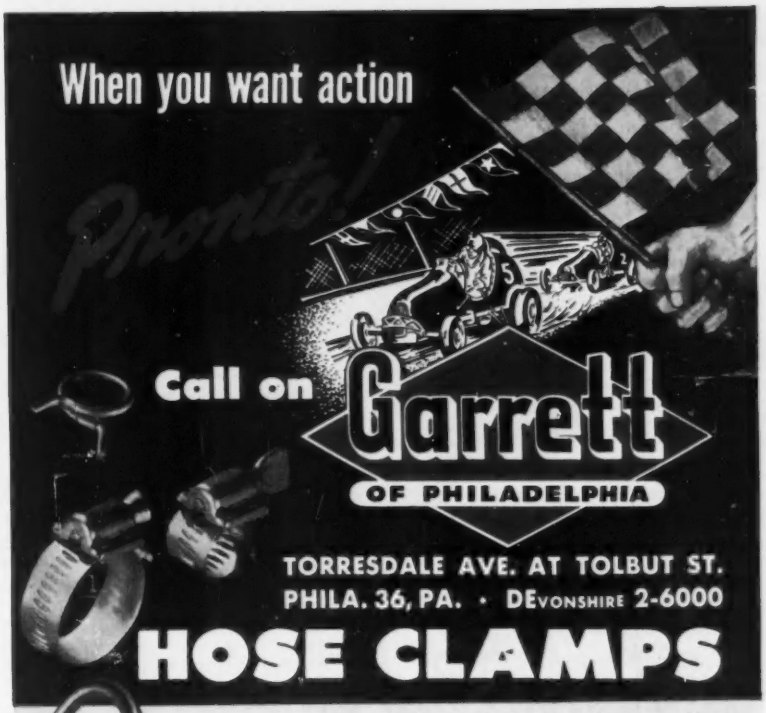
Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

MULTIPLE V-BELTS AND V-BELT DRIVE STANDARD—Brochure, 32 pp. Proposed standard on dimensions of V-belts and V-belt drives available for distribution for criticism and comment. American Society of Mechanical Engineers, Standards Dept., 29 W. 39 St., New York 18, N. Y.

EXPANDERS—Mechanically and Hydraulically Powered—Bulletin 557, 10 pp. Gives construction details, specifications, machine pictures and describes the expanding principle, selection, operating, and tooling. A complete sectional drawing shows the internal construction of a hydraulic expander and provides a table of expander specifications and capacities. Included is a glossary of terms and photos of recently produced machines. Grotnes Machine Works, Inc., 5454 N. Wolcott Ave., Chicago 40, Ill.

DRY SCREEN PROCESS—Booklet, 12 pp. Describes the process in relation to printed circuitry. Discusses the problems it can and has solved. Steps in the printing cycle are illustrated. A typical flow chart is included. Dry Screen Process, 1016 Madison Ave., Pittsburgh 12, Pa.



You can't beat Garrett for delivery on Hose Clamps. Our standard sizes of MULTI-CLAMPS, the clamp of 1,000 high pressure uses . . . AUTO-SEAL, the economy clamp for every industrial use . . . and SPRING-GRIP, the speedy, low-cost wire clamp . . . run the full length of industry's needs—and we can make immediate delivery regardless of quantity. Garrett STATISTICAL QUALITY CONTROL is your assurance of "Double Quality" precision products.

Depend on GARRETT for all small parts.

FLAT WASHERS—Made to meet new ASA and SAE standards . . . available in steel, brass, bronze, monel, aluminum, and stainless steel . . . finished to your specifications.

HELICAL SPRING LOCK WASHERS—with controlled tension for tighter assemblies.

SPRING WASHERS—Belleville, Bevel, 3-Wave, 4-Wave and other Spring Washers of special design.

METAL STAMPINGS—Made to your specifications on high-speed production presses.

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☐ HELICAL SPRING LOCK WASHERS ☐ STAMPINGS
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Here's Use

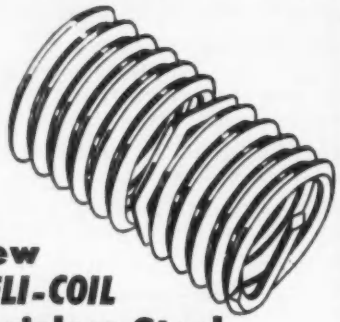
HELI-COIL Stainless Steel Screw-THREAD Insert

This is the insert that permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration and shock. Made of (18-8) stainless steel wire, cold-rolled into a diamond shaped cross-section, this ***Heli-Coil*** Insert is work hardened to a tensile strength of approximately 200,000 psi . . . conforms to military standards MS 122076 through 122275 (ASG) and MS 124651 through 124850 (ASG) . . . conforms to standard commercial and industrial thread forms, including coarse, fine, pipe-thread and MM sizes . . . permits use of standard boss configurations.

Here Are

Save Space, Weight and Costs

Substantial savings in materials, weight, space and costs are possible, as against solid bushings, because smaller (or standard) bosses, flanges and threaded fasteners can be used.



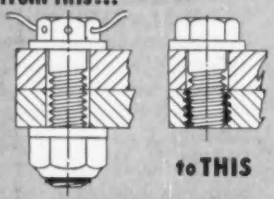
New HELI-COIL Stainless Steel Screw-LOCK Insert

Pat. Pending.

Conforming to military specifications for locking torque and vibration, this notable new ***Heli-Coil*** Screw-LOCK *one-piece* insert provides all the thread protection of the Screw-THREAD Insert, **PLUS** an exclusive internal locking feature that eliminates the need for clumsy protruding lock nuts, lock wiring and other supplementary locking devices . . . saves cost, space and weight . . . permits simplified streamlined design. The Insert is a permanently integrated part of the component—permits repeated service repair disassembly and reassembly, *with locking action remaining unimpaired.* Available in sizes from 4-40 up.

Here Are

from this...

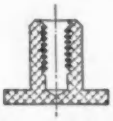


to THIS

Internal Locking Feature

Insures positive internal locking action—eliminates lock nuts, lock wiring and other protruding locking devices—saves space, weight, cost. Yet screw may be easily disassembled with no loss of locking torque.

➡ ***Heli-Coil*** **Field Engineers are at your service for**



CUSTOM LOCK NUTS

The ***Heli-Coil*** Screw-LOCK Insert is adaptable to special-shaped lock nuts, shells, spacers and fasteners and can be engineered to meet your torque or performance requirements. ***Heli-Coil Corporation*** is fully equipped to manufacture these special lock nuts to your specifications.

Note: Custom nuts, with Screw-LOCK Inserts, meet military specifications for lock nuts.

How Design Engineers *HELI-COIL*® INSERTS to

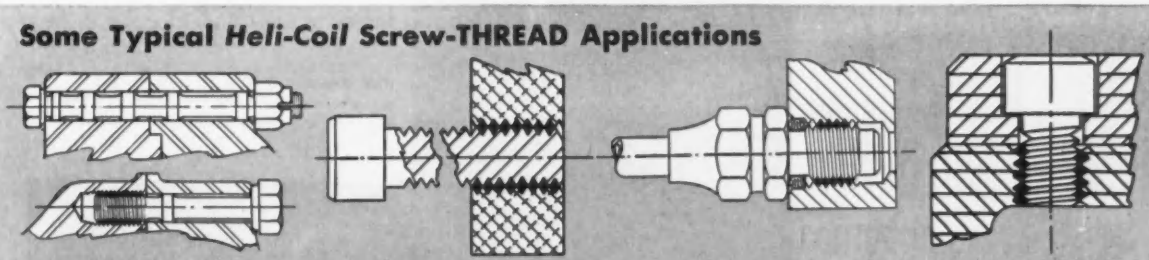
SAVE: SPACE—WEIGHT—COSTS

PERMANENTLY PROTECT THREADS AGAINST

ABUSE • WEAR • CORROSION • STRIPPING • GALLING • SEIZING • VIBRATION

Eliminate Lock Nuts—Lock Wiring—Lock Washers

Some Typical *Heli-Coil* Screw-THREAD Applications



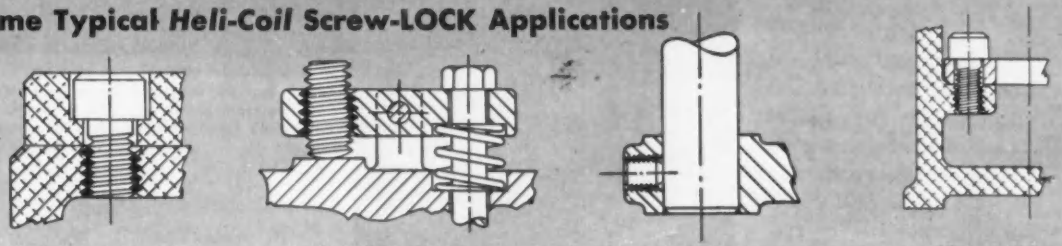
Compact Design
Improves design features by elimination of nuts, washers and extra-length bolts.

Stronger Thread Connections
Under excessive tension, torsion and impact loads in standard proportion bosses, the screw will break but the *Heli-Coil* Screw-THREAD Insert will remain undamaged . . . even in light alloy metal.

Leak-Proof Connections
In lightweight, high pressure hydraulic equipment, stainless steel inserts, regular and pipe thread, protect threaded pump and valve ports sealed with "O" rings.

Steel Threads in Wood, Plastics and Fiberglas
Provides permanent, strong, corrosion-resistant and wearproof threads in soft materials. Especially valuable where frequent assembly and disassembly is necessary.

Some Typical *Heli-Coil* Screw-LOCK Applications



Flush Nut Assemblies
Permits a securely locked, flush assembly, because its internal locking feature eliminates need for drilled head bolts and other protruding locking devices.

Lock Adjustment Screws
This simple design allows permanent, positive adjustment of screws in any position, secure against vibration or impact.

To Lock Set Screws
Positively locks assembly against loosening at desired adjustment—protects threads against stripping under high torque—permits use of light housing materials.

Inaccessible or Miniaturized Assemblies
Heli-Coil Screw-LOCK Insert permits installation of the locking feature from front or top. No blind fumbling for assembly of locking devices inside or behind.

design consultation—without obligation.

HELI-COIL CORPORATION

A Division of Topp Industries, Inc.

*Reg. U.S. Pat. Off.

HELI-COIL CORPORATION
609 Shelter Rock Lane, Danbury, Conn.

Gentlemen: Please send me further information on

- ☐ *Heli-Coil* Screw-THREAD Inserts.
- ☐ *Heli-Coil* Screw-LOCK Inserts.
- ☐ *Heli-Coil* Custom Lock Nuts.
- ☐ Have a *Heli-Coil* Thread Engineer call—without obligation.

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FIRM_____

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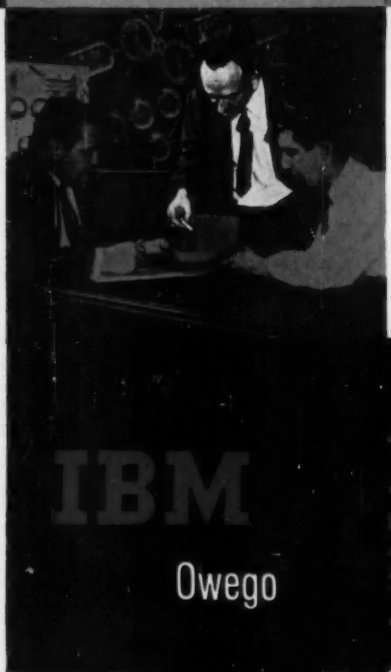
In Canada: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

Project Engineer Robert J. Cantwell uses a system of gimbals to describe navigational problem in the analysis of a new system design.

Development Engineer J. Robert Holmes computes, with other systems reliability analysts, the operational worth of a bombing system.

You'll find a new challenge DEVELOPING airborne computers at



Staff Engineer William Howard reviews gearing accuracy requirements of test equipment with electronic circuit designers.

Circuit Development Group Leader Ralph Wolcott considers future changes in computer output unit for bombing-navigational systems.

The design and development of BRANE (Bombing RAdar Navigation Equipment), now being installed in B-52 aircraft, offer stimulating new challenges to creative engineers at IBM Owego.

Projects currently in process include: Inertial guidance... display equipment ... radar data presentation ... digital and analog systems ... transistor circuit packaging ... test equipment ... installation.

If you are an electrical or mechanical engineer, a mathematician or a physicist —and want to do development work— you owe it to yourself to investigate the exciting possibilities that airborne computers offer you at IBM Owego.

Development Engineer John Walsh discusses the use of a recording storage tube at IBM's Airborne Computer Laboratories, Owego, N. Y.

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Tangents...

Those Not-So-Good Old Days

One of the most-publicized recent copies of ancient designs is *Mayflower II*, a faithful replica of the original except for one beam which had cracked, so was strengthened. And like the original, the ship proved a cranky sailer, subject to all the vagaries of wind and lack of it. She was never a particularly good design, and certainly not well suited to handling her 102 Pilgrim passengers (the steerages of 1910 ships were far less crowded and inconvenient). But she became famous through a fortunate twist of fate, has stayed famous because her passengers were so prolific—at least in present-day claims.

These comments are made as the result of a "sailing" trip on Long Island Sound a few weeks back, directed at seeing *Mayflower II* sail past into New York. But the wind was so strong, we were forced to rely on a lowly engine to get us out into the Sound. And *Mayflower II* couldn't sail either; she waited until dark, then sneaked in under tow of a squat tug.

Even next morning, when *Mayflower II* began her triumphant entry across New York Bay, she was reduced to chaos by a modern helicopter—or rather, two of them. The first was trailing a sign protesting commercial over-tones of the venture (the sign: "White Man, Go Home"!!); the second was a police whirlybird giving chase. They took the wind from Mayflower's sails—so that a tug had to go back to work.

Here is the perfect example of the sturdy design of the "good old days." It was empirical; it grew like Topsy from mistakes. And took an unearthly long time to do so. Perhaps that was one of the elements of the "good" aspect—things changed so very slowly that few people were troubled or stressed.

Today, with scientific approaches to design, the rate of change is much greater, and the engineer begins to attain the economic and social status he deserves. Business moves ahead at an accelerating pace; every American has more money to spend and more time to spend it.

What is the result? We plunge ourselves into a romantic world of long ago. We sail, or ride horseback, or shoot the bow, or collect ancient automobiles, or build and operate model steam locomotives. And everybody talks of the good old days.

Note, however, that we apologize, or overlook, the patent inadequacies of these relics—or we sneak in such modern touches as dacron sails, stainless fittings, nylon lines, and all the rest. The "good old days" are improved by modern touches.

Then there's the "do-it-yourself" craze, with all the rationalizing about hand work, craftsmanship, and the like. From a practical standpoint, some of it is romanticizing; the rest is unwillingness to pay present-day labor costs to have somebody more skilled do the job properly.

It's a slightly more practical aspect of the romantic notion that makes a city woman keep a hunting dog in an apartment; a ranch-house owner decorate his lawn with wagon wheels, bits of fence, and old iron kettles; and a householder seek for her house a fireplace that smokes, antique furniture that collapses under modern people, and coffee grinders planted with ivy. This is as synthetic as the corner bar that re-installs gas lights and checked tablecloths to reproduce the good old-

(Continued on page 184)

"Hold everything, men! The plane you're designing has been declared obsolete!"

O-M Built-in QUALITY

Means Built-in ECONOMY

O-M Tie-Rodless Cylinders
150 PSI Air—Up to 1500 PSI Oil
Meet JIC Standards
Fit Where Others Won't

O-M cylinders were designed with both the "Original Equipment Manufacturer" and the "User" in mind.

Space-Saving – O-M is the original compact "Fits where others won't" cylinder, allowing smaller castings to be used in machines, or "More power for same space"—easily oriented ports – aids in design problems.

Best of Materials – Precision honed steel barrels, bronze bearing surfaces, machined steel end covers, highly polished chromed piston rods, rod scrapers, proper packings for the various operating mediums and pressures – just to mention a few.

Long Life – Quality material, accurate machining, fine finished, proper bearing materials, precision assembly, individual testing are assurances of long life.

Easy Maintenance – The internal key feature not only makes it possible to save space and to easily orient ports, but also makes it easy to disassemble, inspect, clean, repair and reassemble – thus further reducing costly downtime.

Original Cost – Priced right! Compare prices and quality to be convinced.

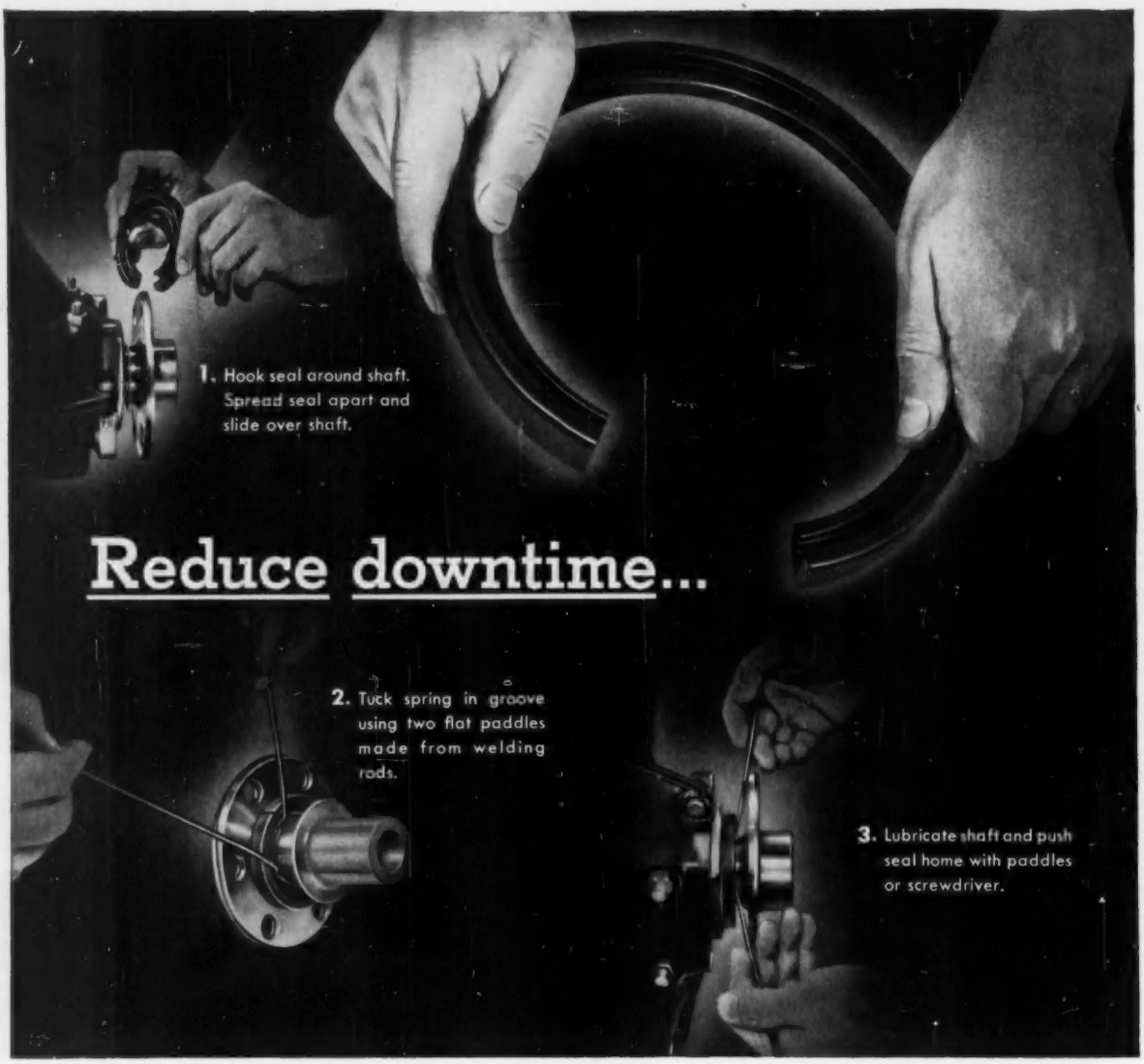
O-M Air and Hydraulic Tie-rodless Cylinders are available in a complete range of sizes (1 ½" to 8" bores) with standard or heavy duty rods. Completely interchangeable parts and mounts. Immediate delivery on many sizes.

Mail coupon at once for Bulletins 101A (O-M Tie-Rodless Air and Hydraulic Cylinders) and 105 (O-M Series T-H — Heavy duty Hydraulic Cylinders)

ORTMAN-MILLER MACHINE CO.
15 143rd Street, Hammond, Indiana

☐ Have representative call
☐ Send Bulletins 101A and 105

Name_____ Position_____
Company_____
Address_____
City_____ Zone____ State_____


1. Hook seal around shaft. Spread seal apart and slide over shaft.
Reduce downtime...
2. Tuck spring in groove using two flat paddles made from welding rods.
3. Lubricate shaft and push seal home with paddles or screwdriver.

How J-M Split Clipper Seals speed installation

. . . flexible body provides easy installation and removal even with small clearances

"Downtime" is measured in seconds when Clipper Seals do your sealing. Furnished in split form and made from a highly flexible synthetic rubber compound, they can be readily slipped into the tightest spots. Neither special training nor special tools are required . . . no drilling and tapping for cover plates is necessary because cover plates are not needed.

Clipper Seals are virtually fracture-proof and stand up well under rough handling by inexperienced mechanics. The self-adjusting garter spring has a hook and eye which is easily hooked around the shaft. It is then a simple procedure to slip it into the groove. When the shaft end is accessible, solid seals are used and snap into place almost as quickly as you can say "Clipper Seal." What's more, they stay put.

Reduced "downtime" is only one of many advantages you get with J-M Clipper Seals. Precision moulded from a variety of corrosion-resistant compounds specially developed for each service, they provide maximum sealing ability, low torque, long life and wide adaptability. For more information on the complete line of Clipper Seals, write for new 28-page illustrated brochure PK-71A. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

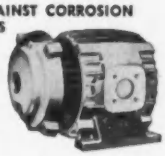
JM PRODUCTS

Johns-Manville CLIPPER SEALS

rough CONDITIONS?

U.S. TOTALLY-ENCLOSED MOTORS

Protected **AGAINST CORROSION ALL EXPOSED PARTS CAST IRON...**



Rust-resistant solid cast iron withstands abuse, wear and corrosion. *Protects* working parts!

Protected **BY LUBRIFLUSH FOR LONGER BEARING LIFE**

New grease forces old grease out—keeps bearings fully lubricated. *Protects* bearing efficiency!

Protected **AGAINST INTERNAL HEAT WITH ASBESTOS WINDINGS**

Nature's greatest heat resistor, asbestos can't carbonize! *Protects* windings against heat!

Protected **FROM STRESS AND WARP BY NORMALIZING CASTINGS...**

All cast-iron components are heat-seasoned to stabilize molecular structure. *Protected* against warp!

Total Protection in every direction

Large savings are being gained by many industries using *enclosed* motors in place of the usual "open" or ordinary protected motor. U.S. Totally Enclosed gives *total* protection in every direction—from corrosion, dusts, abrasives, impact, weather, spray and splash! This means motor dependability ...long life...savings both on motor costs and production continuity!

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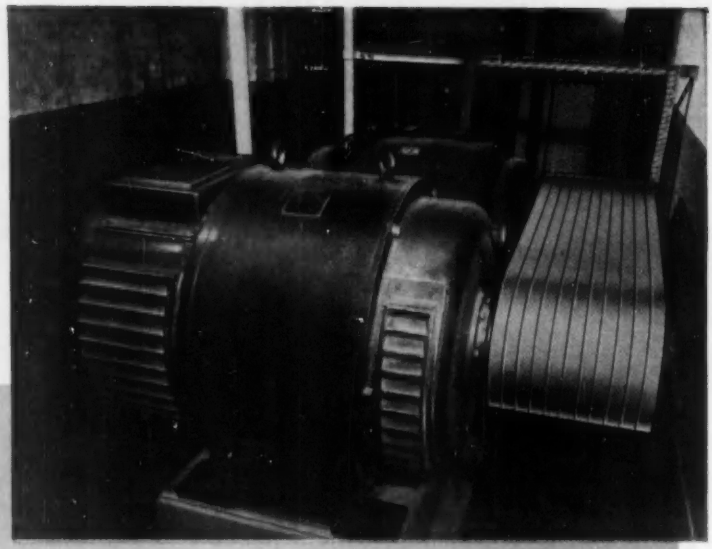
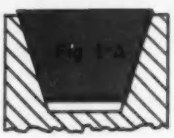
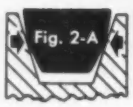


How CONCAVE SIDES cut V-belt costs

By this simple test you can see for yourself how the concave sides (Fig. 1) of the Gates V-Belt lengthen the life of the belt... *thus reducing costs.*

Just bend a Gates V-Belt and feel the sides. You will see that these precisely engineered concave sides have now *become straight*, permitting them to grip the sheave groove evenly. (Fig. 1-A). This assures longer belt life; lower costs.





Now make the same test with a straight-sided belt. (Fig. 2) Notice how the sides bulge out on the bend (Fig. 2-A) concentrating the wear at the points shown at arrows.

These tests should convince you that it *pays* to specify the V-Belt with Concave sides—Gates Vulco Rope...readily available from nearby distributors.

THE CONCAVE SIDE
U.S. PAT. NO. 1813698

TPA 199

Gates Distributors are in the Yellow Pages

World's Largest Maker of V-Belts

The Gates Rubber Co.
Denver, Colorado

There are Gates Engineering Offices and Distributor Stocks in all industrial centers of the U. S. and Canada, and in 70 other countries throughout the world.

Gates VULCO ROPE Drives

fashioned saloon—in everything but prices.

This is stage dressing, part of the urge to be different in a world becoming increasingly standardized. The man who in dress, habits, income, and most other visible characteristics is just as like his neighbors as their houses are like his, suddenly blossoms forth with a trick beard, a purple awning, or a queer breed of dog. That's his claim to distinction, a resurgence of the independence that once made every man live alone against a hostile world.

The hobby is often another expression of individualism—the effort to excel at something, be it flagpole sitting, flying upside down, or swallowing goldfish. From this urge come the Eiffel Towers glued together from kitchen matches, the castles of newspaper wadding, and other examples of endless hours of effort, little inspiration, and products that are amazing, but hardly lasting or important. They express individuality of a somewhat terrifying kind.

A major requirement of many hobbyists is that the best possible job be done—sometimes a better job than the individual does at his vocation. Thus the golfer tries to outscore his opponent, the gadgeteer tries to produce something bigger, wider, more complex than others have produced. This converts the hobby into work, and defeats its purpose—always assuming the hobby is supposed to be relaxation.

I well recall sailing one day with an editor who owned a sailing dinghy. It was too small to sail anywhere but inside a bay. We were, therefore, beating back and forth across the local harbor—going nowhere, and pleasantly. But he wasn't content with that; he continually adjusted the single sail and fiddled with the tiller to get a bit more speed. Why? To make more round trips across the harbor? He insisted that I, as an engineer, should be interested in getting the last ounce of speed from that cockleshell. As an engineer, I should, but would an engineer working at his job try to do such an inefficient operation efficiently? Obviously not—he'd change the method, or the objective.

Do we romanticize the obsolete because of an innate fear that we may someday be forced back to its use? Do

(Continued on page 188)

Extending
high production
advantages to an

unlimited new range

of specifications
in fasteners and
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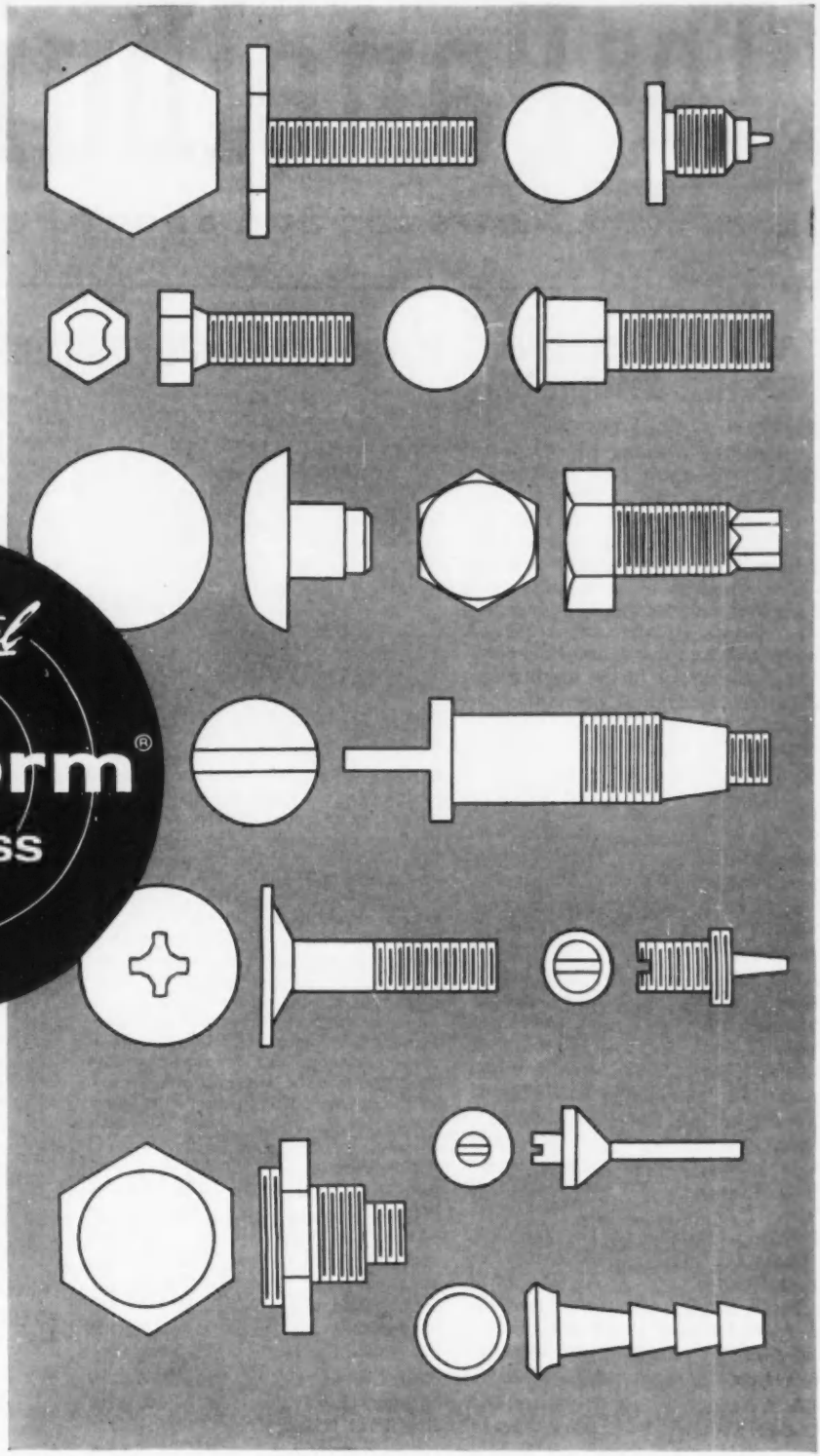

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The Panelbuilder

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MOTOR CONTROL

News for and about Panelbuilders

55 CUTLER-HAMMER OFFICES SERVE EVERY INDUSTRIAL AREA

Recently Cutler-Hammer announced the opening of new sales offices in Medford, Ore. and Louisville, Ky. With the addition of these two offices, the number of sales offices now totals 55 serving every industrial area. In addition to these offices there is a nationwide network of Authorized Cutler-Hammer Distributors who maintain stocks of motor control components. For competent assistance in the application of motor control and a reliable supply of control components, contact your nearby Cutler-Hammer Sales Office.

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Atlanta 13, Ga.	210 16th St., N. W.
Baltimore 18, Md.	2319 Maryland Ave.
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Charlotte 2, N. C.	237 S. Tryon St.
Chicago 6, Ill.	400 W. Madison St.
Cincinnati 2, Ohio	804 Plum St.
Cleveland 7, Ohio	1521 W. 117th St.
Columbus 9, Ohio	2700 E. Main St.
Dallas 7, Tex.	1331 Dragon St.
Davenport, Iowa	220 Main St.
Dayton 2, Ohio	410 W. 1st St.
Denver 4, Colo.	126 W. 5th Ave.
Detroit 38, Mich.	15427 Woodrow Wilson Ave.
Fresno 21, Calif.	155 Van Ness Ave.
Grand Rapids 2, Mich.	403 Bldg. & Loan Bldg.
Houston 6, Tex.	3305 Montrose Blvd.
Indianapolis 5, Ind.	644 E. 38th St.
Kansas City 6, Mo.	903 Grand Ave.
Los Angeles 22, Calif.	6431 Bandini Blvd.
Louisville 6, Ky.	2416 Frankfort Ave.
Medford, Ore.	1320 Queen Anne Ave.
Midland, Tex.	4017 Roosevelt Blvd.
Milwaukee 9, Wis.	2312 W. Capitol Dr.
Minneapolis 15, Minn.	523 S. 7th St.
Newark 5, N. J.	315 Sherman Ave.
New Haven 18, Conn.	2331 Whitney Ave.
New Orleans 12, La.	833 Howard Ave.
New York 18, N. Y.	8 W. 40th St.
Omaha, Neb.	320 W.O.W. Bldg.
Philadelphia, Pa.	65 West Ave., Wayne, Pa.
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Portland 4, Ore.	208 S. W. Stark St.
Richmond 19, Va.	13 E. Franklin St.
Rockford, Ill.	1404 N. Main St.
Sacramento 17, Calif.	1331 T St.
Saginaw, Mich.	107 N. Franklin St.
St. Louis 3, Mo.	1914 Washington Ave.
Salt Lake City 1, Utah	165 S. 1st, West
San Francisco 7, Calif.	2130 3rd St.
Scranton 10, Pa.	836 Jefferson Ave.
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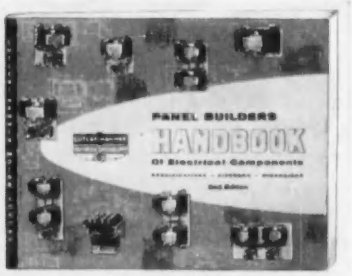
ROTO-PUSH SIMPLIFIES CONTROL PANEL DESIGN

Cutler-Hammer's Roto-Push Control Unit offers amazing opportunities for simplified compact control panel and master station design. Roto-Push combines the pushbutton and selector switch into a single control unit that will perform all the control functions which normally require two or three separate units. The control circuit is selected by rotating the knurled guard ring to the proper position, and the operation is actuated by depressing the pushbutton. The Run-Safe-Jog Roto-Push unit illustrated is typical of many common functions that normally required two or three control units. With the guard ring in the "Run" position, circuit is set up that is maintained after the pushbutton actuates the operation. With the guard ring in the "Jog" position, the operation is actuated only as long as the button is depressed. The "Safe" position prevents accidental starting of the machine.

Circuitry Unlimited

Roto-Push operators are available in two and three position selector rings. Further there are six cam variations of the two position unit and two variations of the three position element. The double pole contact blocks that are used with the Roto-Push operators are available in any combination of normally open and normally closed contacts. Even the most involved circuits can be arranged with the Roto-Push control unit because of its wide choice of operators, cams and contact blocks. Roto-Push control Units are oil-tight and suitable for either one-hole mounting or base mounting. For further information write on your company letterhead for Cutler-Hammer Master Design Pub. EL-178.



PANEL BUILDERS HANDBOOK SIMPLIFIES SELECTION OF ELECTRICAL COMPONENTS

This handy 67 page reference guide is specifically edited to assist design engineers and control panel builders in the selection of electrical control components and control accessories. Every effort was made to make this book as concise as possible, and yet it includes such vital information as wiring diagrams, dimension drawings, ratings, ordering information and a maintained price list. Address your request for a personal copy on your company letterhead. CUTLER-HAMMER, Inc., 1332 St. Paul Ave., Milwaukee 1, Wisconsin.

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LOW COMPRESSION SET

Butyl "O" RINGS

NEW

Another LINEAR first . . . a new, low compression-set Butyl Compound for use in "O" Rings. LINEAR Butyl Compound 7806-70 is a seal material that withstands compression set at elevated temperatures without being permanently deformed or losing its resiliency and its value as a seal. Also, Butyl withstands the chemical actions of the non-flammable phosphate esters such as "Skydrol", "Pydraul", "Celluflex" and "Lindol".

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Exhaustive tests, under method "B" of the ASTM, show this new LINEAR compound develops only 30 to 40% compression set after 70 hours at 212°F, as compared to the usual 70 to 95% set experienced with previous Butyl compounds. This unusually good resistance to permanent deformation, combined with a tensile strength of 2000 psi and an elongation factor of 275%, make this material an outstanding one for all "O" Ring applications and other molded shapes where Butyl rubber's excellent qualities are desirable.

Whenever you have a seal problem that is tough to handle—look to LINEAR for an answer. Write, or ask the local representative for complete information on LINEAR's new Butyl Compound 7806-70—today.

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Intricate shapes . . . unusual contours . . . fine detail . . . metals and alloys difficult to machine . . . rigid quality control specifications . . . unyielding performance requirements—These are production "headaches" ARWOOD can cure, without difficulty.

Expert research, design and development staffs, multi-plant tooling, casting and finish-machining, Government-approved, in-plant heat treating and inspection, 54 field engineers in 20 major industrial centers . . . ARWOOD's prescription for the cure. Do YOU have this kind of headache? Write TODAY for literature on our "prescription"!

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we instinctively follow the Boy Scout motto, "Be Prepared"—our preparation consisting of having a little knowledge of the most elemental things? Are we, as a result of bomb scares, total war, dangers from fall-out, and even such mundane things as dodging automobiles and observing sun explosions, anticipating a return to savagery, or primitiveness? Or is this all the instinctive fear of the unknown future that psychologists say plagues us all when we relax?

Otherwise, why romanticize the inefficient and ineffectual? A startling evidence of it (and one that is subject to a host of other explanations) is in this quote from *To See the Dream,* by Jessamyn West: "When I was a girl, the height of feminity was to be flat chested. . . The changed attitude toward the breast is the same as the changed attitude toward the wagon wheel, the coffee grinder and the fireplace. We romanticize whatever we have outgrown as necessity, but about which memories still cluster. . . And the bigger the better. Modern living rooms have fireplaces you can walk into. Conspicuous consumption is the model here. And to have a big nonuseful object is about as conspicuous as you can get.

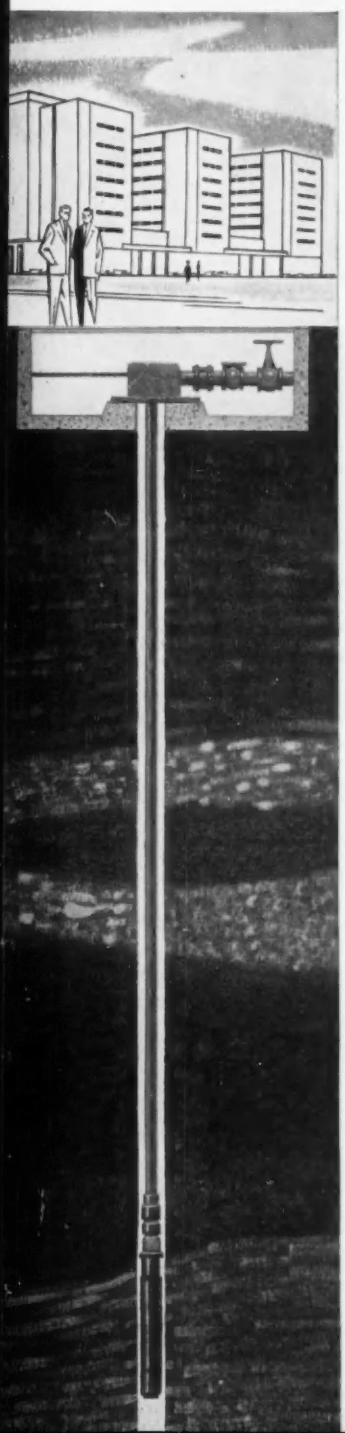
"And since it is no longer functionally needed, the breast, like fireplace, wagon wheel and coffee mill, is displayed, augmented and gilded. The big breast, since the advent of the infant formula, has become a kind of antique, and a man enjoys owning one or two and displaying them for the same reason that he enjoys owning a piece of Paul Revere silver or a 1902-model Reo."

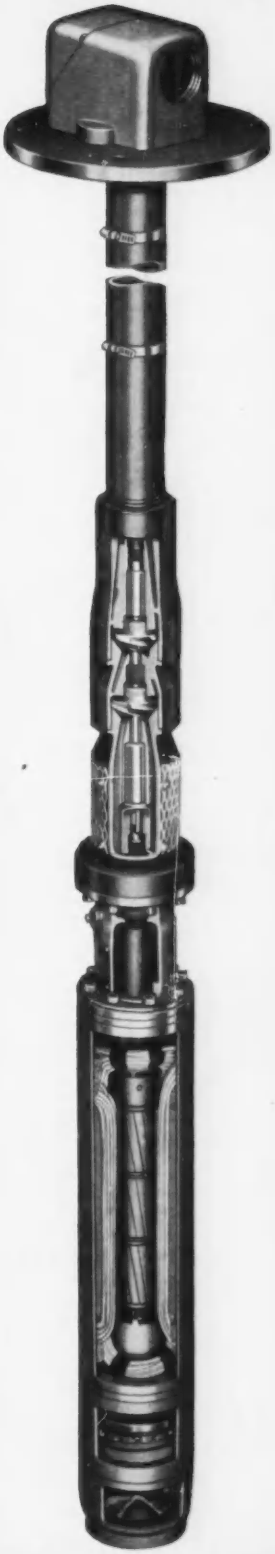
This could be debated endlessly, to no decision. But it is a dramatic example of the thing we're talking about. Real engineering talent designed the wire structure of the strapless bra—but it was a movie scout who introduced Italian women and their monumental dimensions to the American moviegoer. The serious question is whether any engineered structure can do the job if competitive-minded American women decide this is the direction in which to go.

Now, having arrived at the most romanticized subject among men—and one of the most practical among women—there is no more to be said.

—E.J.T.

Now you can bury your pumping problems





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Water-Lubricated Submersible Pump

Now you can have all the advantages of a submersible pump, plus time- and performance-tested Fairbanks-Morse features.

Fairbanks-Morse submersible pumps permit well location anywhere that a well can be drilled. No unsightly installations, no costly pump housing. Nothing—absolutely nothing—need show above ground. These pumps submerged in the well below water level are practically soundless and require no line shafts, packing boxes or lubrication devices. Hence, wearing parts needing maintenance are reduced to a minimum. A single moving assembly does all the work.

Installation is faster and more economical. The Fairbanks-Morse motor, with lifetime Copperspun rotor cooled by water and lubricated by water, gives full motor output. The well-known Fairbanks-Morse or Pomona pump bowls are combined with these wet stator motors to produce unbeatable pumping units covering a wide range of requirements as to volume, pressure, and setting depth.

For industry or community service you can place your water service trust in the F-M submersible. Contact your Fairbanks-Morse Sales Engineer and ask him for Bulletin 6910 on this time-proved submersible pump, or write today to Fairbanks, Morse & Co., Dept. PE-9-16, 600 S. Michigan Avenue, Chicago 5, Illinois.

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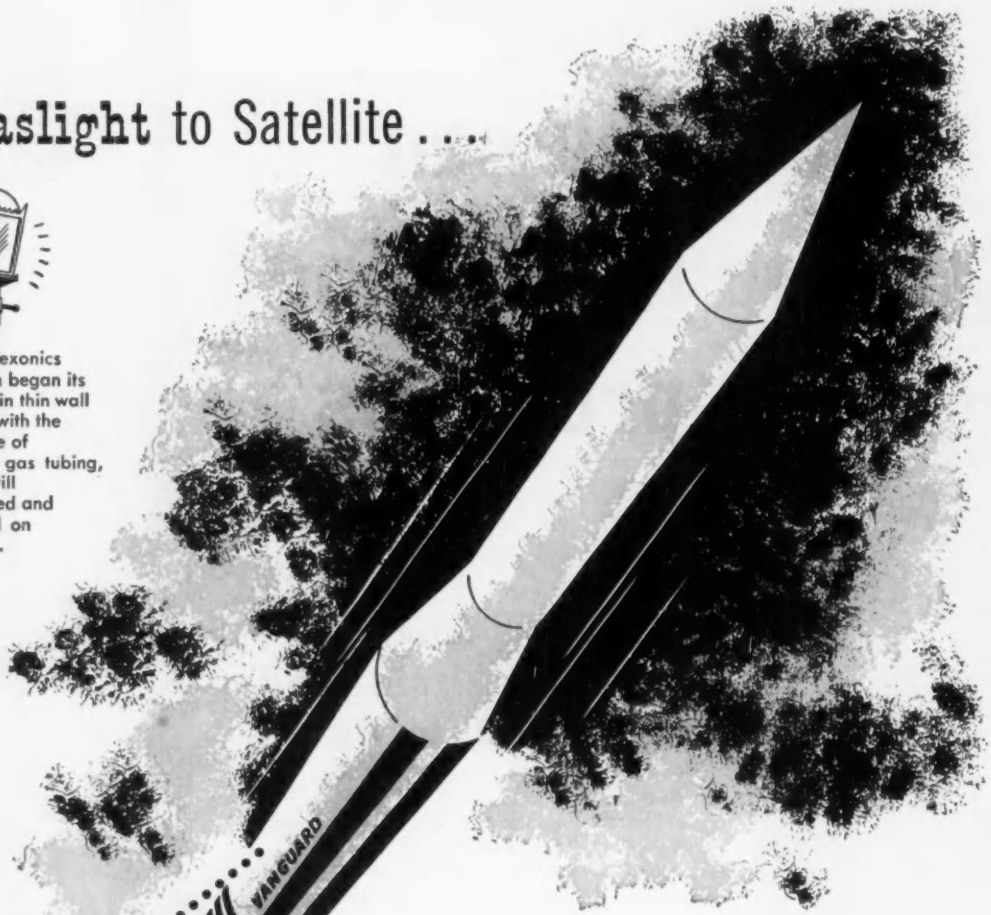
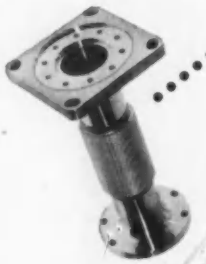
From Gaslight to Satellite . . .

IN 1902 Flexonics Corporation began its experience in thin wall assemblies with the manufacture of "Kantleke" gas tubing, a product still manufactured and widely used on gas heaters.





IN 1957 IN THE HEART OF THE VANGUARD, a high performance flexible connector by Flexonics. Proofed at 1500 psi, it will go to work in the first stage of the earth satellite launching vehicle in the International Geophysical Year.

*Du Pont trademark, licensed by Resistoflex Corp.

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As a pioneer in the design and fabrication of flexible hose, connectors, ducting and related items, Flexonics Corporation is proud to be the supplier of critical assemblies for many of the nation's most advanced projects.

The unmatched know-how of Flexonics Corporation that led to this selection is available to help you. Your requirements will be met with applications incorporating the newest proven techniques and the most advanced thinking of the industry.

Included among Flexonics products are metal, synthetic and Teflon* hose . . . metallic bellows . . . aircraft components . . . piping expansion joints for low, medium and high pressures.

For engineering assistance or product application data—call or write, today

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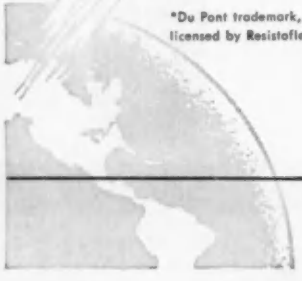

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CLARE RELAYS and AUTOMATION

Cutaway view of CLARE Mercury-Wetted-Contact Relay, two of which are used by AccuRay to control cigarette making process.

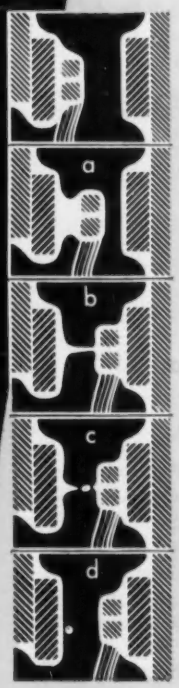
How *AccuRay*® uses long-life CLARE Mercury-Wetted-Contact Relays to provide accurate, continuous and automatic control of a manufacturing process

Actuated by variations in the electric current set up by a constant intensity beam of radiation through a cigarette "rod," two CLARE Mercury-Wetted-Contact Relays help the AccuRay Cigarette-Gauge controller to proportion the weight of cigarettes as they are being produced.

In this way AccuRay, a revolutionary precision process control system, uses electronics to provide automatic control of cigarette and other manufacturing production processes.

Engineers of Industrial Nucleonics Corporation, makers of this new process control, picked CLARE Relays to perform these important functions because only these relays gave the long life and low maintenance required. These machines wrap and cut 20 cigarettes a second, day and night, day after day.

With a service life of billions of operations* it is no wonder this relay has become the first choice of hundreds of leading designers of computing, data-processing and control equipment. For complete information write for Bulletins 120 and 122 to C. P. Clare & Company, 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: 659 Bayview Avenue, Toronto 17. Cable address: CLARELAY.



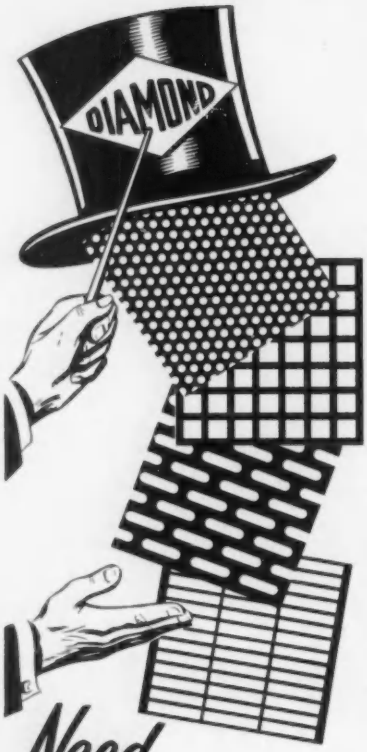
Drawings (left) from high-speed photographs show the cycle. (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing globule of mercury to fall out. Mercury flows up the capillary path, replaces amount lost, restores the equilibrium. (d) The momentary bridging of the parting contacts—and the extremely fast break that ends it—minimizes the arc and adds greatly to contact load capacity. Contact closure between the two liquid surfaces bridges mechanical bounce and prevents any chatter from appearing in the electrical circuit.

More than two years ago a life test started on a group of these relays carrying a full contact load of ½ amperes at 50 volts d-c with suitable spark suppression. They have been operating continuously ever since at 5,184,000 operations a day. They have now passed the 4 billion mark—and the end is not yet in sight.

CLARE RELAYS

FIRST in the industrial field

® Industrial Nucleonics Corporation, Columbus, Ohio



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QUICK ACTION on Perforated Metal Sheets or Parts?

We're not magicians — can't pull rush jobs out of a hat — but when quick action is needed we're usually able to ship on the specified date; or even a little sooner.

One reason is because we carry large quantities of all commonly used metal sheets and plates IN STOCK. Another reason is because we HAVE hundreds of modern tool arrangements, for a great variety of attractive perforating patterns, in a wide range of sizes. If a special pattern or layout is needed, for some particular purpose, we can MAKE the necessary tools to order.

Engineers and Designers will find all the information they need, to make a quick, accurate, selection from standard Diamond perforating patterns and sizes, in our 36-page Catalog No. 39. No charge or obligation: we're glad to send it to anyone who can use it to advantage. Estimates submitted promptly.

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17915 So. Figueroa St., Gardena, California
Los Angeles Area

DESIGN ABSTRACTS

Resistance to Rolling and Sliding

In general a single "coefficient of friction" is inadequate to define the frictional resistance between contacting bodies. It is necessary to know both the inclination of the resultant force line and the offset of this line from the theoretical point of contact. This paper presents results of experiments, which were made to determine the effects of velocity on the inclination, and the offset of the line of action of the resultant force between two disks in peripheral contact.

The results indicate that the sliding velocity is of primary importance in determining the inclination of the line of action of the resultant force. It is the sum of the sweep velocities that is of primary importance in determining the offset of the resultant force line. The nature of the relationship between the angle of inclination and the offset of the line of action of the resultant force, and the proximity of the contact conditions to those existing for pure rolling, was investigated but no conclusive results were obtained.

Abstracted from "Resistance to Rolling and Sliding," by A. C. Dunk and A. S. Hall, Jr., The American Society of Mechanical Engineers Paper No. 57-SA-9, June 9-13, 1957.

Factors in Cold Extrusion of Metals

Pressure required on the punch in cold extrusion is dependent on material extruded, degree of deformation, forming speed, operating temperature, punch shape and friction.

Each material has characteristic cold working properties which vary only with heat treatment and amount of previous cold work.

Degree of deformation to be obtained by extrusion has a linear relation to force required.

Influence of forming speed has not been determined as presses do not permit sufficient variation in speed.

Normally the material starts out at room temperature, 15 to 20 C. The rise in temperature that occurs during extrusion is due to frictional energy. In fast mechanical presses where there is no time for substantial transfer of this heat to the punch and die walls, temperature in the blank may rise to 200 C, but this rise in temperature is not accompanied by a drop in the pressure required.

Shape of punch has a large influence on force required, but present knowledge of shape-force relations is purely empirical.

A suitable lubricant can cut in half the force required to form a given material. For steel, surface coating with zinc phosphate followed by limed soap gives best results. This treatment is now standard, so that the influence of friction on total force may be considered constant.

For a given material, therefore, total force required to extrude varies directly with amount of deformation. Plastic forming of the material causes internal stresses that result in work hardening. For a given material, degree of work hardening is a measure of deformation. All deformations along a given axis should be added together regardless of direction, as work hardening is proportional to the sum of the absolute deformations.

As plastic deformation varies between sections of a given part, work hardening is not uniform.

Abstracted from, "Approximate Computations in the Field of Cold Forming," by F. Hrazdil, Research Institute for Forming Machinery and Forming Technology, Brno (Chekoslovakia), Strojirenstvi, Vol. 6, No. 7, 1956, page 476.

The Prediction of Journal-Bearing Temperatures by The Application of Heat-Transfer Theory and Data

The heat generated in the bearing oil film is partly carried away in the oil which flows out the ends of the bearing and partly transmitted by conduction through bearing lining and shell and along supporting walls and the

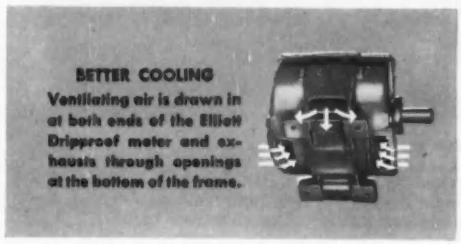
(Continued on page 196)

Inside and Outside . . . entirely new

DRIPPROOF TYPE FRAMES 182-326U

the NEW Elliott C-W Dripproof Motor

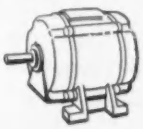
BALANCED DESIGN assures dependable performance


BETTER COOLING
Ventilating air is drawn in at both ends of the Elliott Dripproof motor and exhausts through openings at the bottom of the frame.

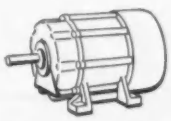
The *balanced* design of the new Elliott C-W type N motors provides the *best* in mechanical protection, the *best* in insulation, the *best* in bearings, the *best* in rigid construction. These motors produce more horsepower per pound, require less space, less maintenance, have longer service life. Every rotor is dynamically balanced. Rigid cast frames assure correct alignment, resist corrosion and mechanical abuse. Highly effective cooling eliminates troublesome hot spots.

The design illustrated above is dripproof—and virtually splash-proof as well. Yet ingenious design has provided ample passages for cooling air. Other types of enclosures providing even greater protection are available for service where conditions are extremely severe.

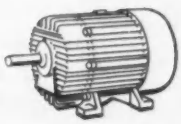
OTHER C-W TYPE N MOTOR ENCLOSURES



Totally-enclosed non-ventilated



Totally-enclosed, fan-cooled Frames 256 U and smaller



Totally-enclosed, fan-cooled Frames 284U-326U

ELLIOTT Company

CROCKER-WHEELER DIVISION

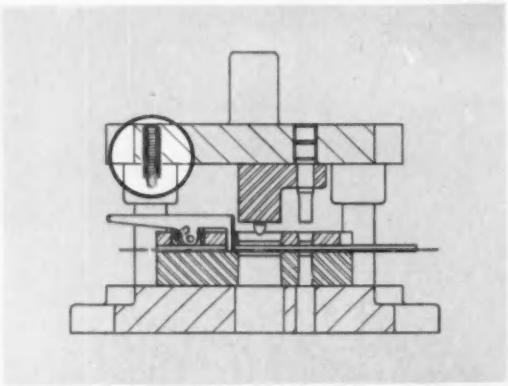
For complete details, send for new booklet. *WRITE* Elliott Company, Crocker-Wheeler Division, Jeannette, Pa.

W6-5

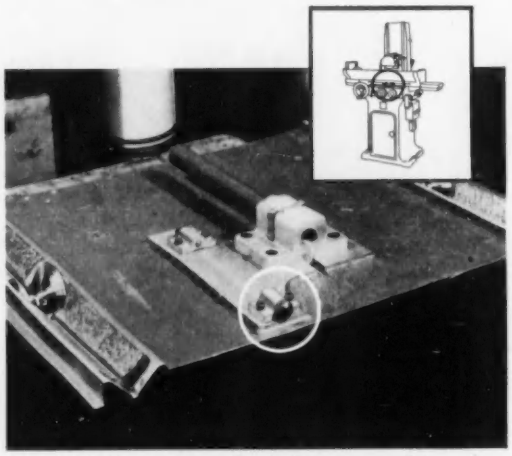
Practical Design Tips

Number 2 of a series.

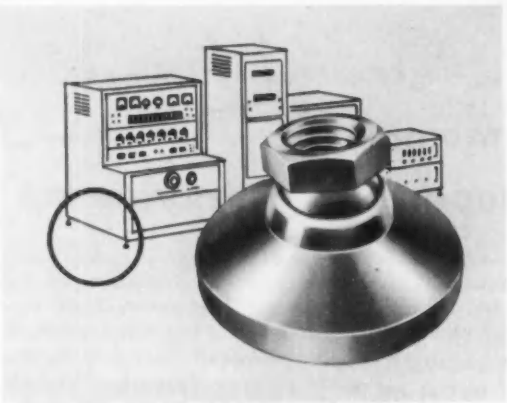
Substituting simple, off-the-shelf Vlier Tooling Accessories for complicated, custom-made devices in both tooling and original equipment applications can result in important savings. Why not put them to work in your plant?



TO STOP SMASHING DIE STOPS, substitute a Vlier Spring Plunger for the usual square-head screw. The plunger actuates the automatic stop perfectly and, unlike the screw, never needs adjusting no matter how many times the die is resharpened. Available in four models: 50 sizes.



TO CUSHION SHOCK as the bed traverses, this surface grinder manufacturer uses two Vlier Spring Stops, reducing wear and tear on the machine. These clever, spring-loaded devices, ordinarily used on fixtures where the absence of side walls prevents the use of spring plungers, are now available in three standard sizes: 3 end pressures. Special sizes made to quantity orders.



TO LEVEL MACHINE TOOLS, electronic racks, benches, etc., use the *standard* Vlier leveling pad. The pad swivels to 7½° each side of the center line; adjusts automatically to uneven surfaces. Unique ball-joint design distributes weight over entire pad surface.

TO GET NEW IDEAS on how to save with Vlier Tooling Accessories, send for new 28-page booklet "Typical Applications of Vlier Tooling Accessories." It suggests dozens of ways to use these time-savers in both tooling and original equipment applications. Write for your copy today.

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Insist on Vlier Tooling Accessories... there's still no substitute for quality!

VLIER ENGINEERING INCORPORATED

8900 Santa Monica Blvd., Los Angeles 46, California

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*TRANSLATION: CUTTING OIL

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Other Outstanding Shell Industrial Lubricants

Shell Tellus Oil—for closed hydraulic systems

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Shell Turbo Oil—for utility, industrial & marine turbines

Shell Rimula Oil—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Dromus Oils, a quality line of soluble cutting oils, permit higher speeds and greater feeds while extending tool life. They have excellent wetting and cooling properties and are not sticky or greasy.

Dromus® Oils have the added advantage of being easy to mix in hot or cold, hard or soft water. They form emulsions which remain stable in practically any concentration required in the shop.

Today Dromus Oils are available to your customers abroad. You can be sure that they will enjoy the same efficient performance your domestic customers rely upon.

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Give your equipment the best circulation system...
If the equipment you design and build depends on the flow of liquid—be sure you specify Ingersoll-Rand Motorpumps to power the circulation system. Ingersoll-Rand Motorpumps are ruggedly constructed, yet compact in design to deliver the volume and pressure you require. From small ¼ hp to 75 hp models, these pumps give you the high efficiency and dependable performance that have made Ingersoll-Rand Motorpumps industry's standard of comparison.
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9-124

shaft. From the boundary surfaces it is transmitted to the surrounding air by convection and to surrounding walls and solid objects by radiation.

Fairly accurate means have recently become available for determining the rate of oil flow out the ends of a plain bearing, hence the heat loss to the oil. This has directed attention to the fact that more information is needed concerning the rate of heat losses by radiation, convection, and conduction. These losses, together with the heat carried away in the oil, may be added and plotted as heat dissipated versus temperature. Equilibrium will be established at that temperature where the heat-dissipated curve crosses the heat-generated curve. Thus, the operating temperature is found from a heat balance diagram.

A sound basis in heat transfer theory, together with coefficients, is presented in this paper for the predetermination of bearing operating temperatures. The rotating shaft is found to be a major source of heat dissipation. To minimize the cut-and-dry nature of the calculations certain approximations are indicated,—uniform temperature throughout the bearing, equal temperatures in bearing and oil film, a central position for the adiabatic plane, and a constant combined convection and radiation coefficient for the shaft. The initial test results with a bearing of cylindrical shape and effective shaft length twice the bearing length justify the

(Continued on page 198)

"There goes value analysis again with their 'Blast and Refine' technique."

Amazing LIVERMONT TORQUE LIMITER

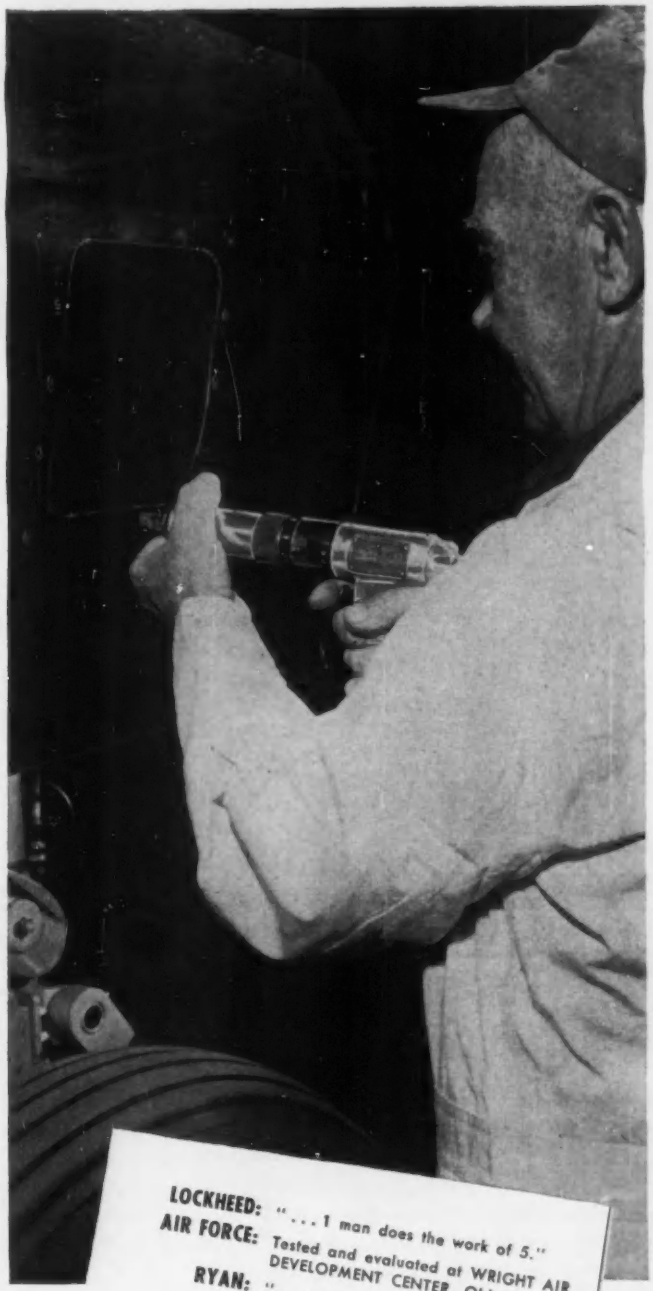
combines power driven speed with hand torque accuracy!

"... reduces bit breakage from 100 per day to 10 in seven weeks".

at CONVAIR

"... this unit was in constant use on wing assembly line, powered by a Buckeye pneumatic drill motor. Through the use of Livermont Torque screwdriver, we were able to reduce the breakage from 100 per day to approximately 10 bits in seven weeks."

Manufacturers all over the United States, like Convair, are proving the Livermont Torque Limiter saves material and labor while actually speeding up production. The Limiter is completely automatic and combines the speed of air-powered tools with the accuracy of hand operated torque wrenches. It will maintain, under all conditions, a positive, accurate torque from 5 to 85 inch pounds with no ratchet or impact effect. The Livermont Limiter eliminates damage to screw heads and has proven itself to be 10 times faster than old methods.



LOCKHEED: "... 1 man does the work of 5."

AIR FORCE: Tested and evaluated at WRIGHT AIR DEVELOPMENT CENTER, Ohio.

RYAN: "... proved to be 10 times faster than former methods."

DOUGLAS: "... Long Beach plant is converting 100% to all air-powered screwdrivers."

NAVY: Tested and evaluated at U.S. NAVAL AIR STATION, San Diego, California.

N. AMERICAN: "... an accuracy rating of 100% was given on the Livermont tool."

BROAD INDUSTRIAL APPLICATION

Designed for wide industrial use, the Livermont Limiter will pay for itself, whether or not accurate torque is essential. The Limiter reduces bit breakage and completely eliminates screw head damage. Built for rugged dependability, the Limiter can be applied with the delicacy and precision of a jeweler's screwdriver.

LIVERMONT, INC. | MAPLE & MYRTLE MONROVIA, CALIFORNIA

AN AFFILIATE OF RICHMONT, INC., • WORLD'S LARGEST PRODUCERS OF TORQUE WRENCHES, SCREWDRIVERS & INSTRUMENTS.

Connors Special Sections

Peaks of Performance

with Allis-Chalmers Model HD-6 Tractor and Connors Special Sections

Allis-Chalmers Manufacturing Company requires quality, close tolerances and delivery as scheduled to maintain the fine reputation of their Construction Machinery.

The answer, one that also resulted in appreciable savings in production costs, was Connors Special Sections, produced by West Virginia Works of Connors Steel Division, H. K. Porter Company, Inc., at Huntington, West Virginia.

Rolled to your specifications, Connors Special Sections can mean big savings, smoother production and highest quality in your manufacture, too.

If your production volume warrants special rolls, contact our Engineering Consultant Service for free assistance. Send your sketch or specifications to West Virginia Works, Connors Steel Division, H. K. Porter Company, Inc., P. O. Box 957, Huntington, West Virginia.

H. K. PORTER COMPANY, INC.
CONNORS STEEL DIVISION

approximations and indicate that basic theory may be successfully applied. When additional experimental data become available, it is hoped that charts may be developed for the further simplification of temperature calculations.

Abstracted from "The Prediction of Journal-Bearing Temperatures by the Application of Heat-Transfer Theory and Data," by A. H. Burr and D. Dropkin, The American Society of Mechanical Engineers Paper No. 57-SA-89, presented at the ASME semi-annual meeting, San Francisco, Calif., June 9-13, 1957.

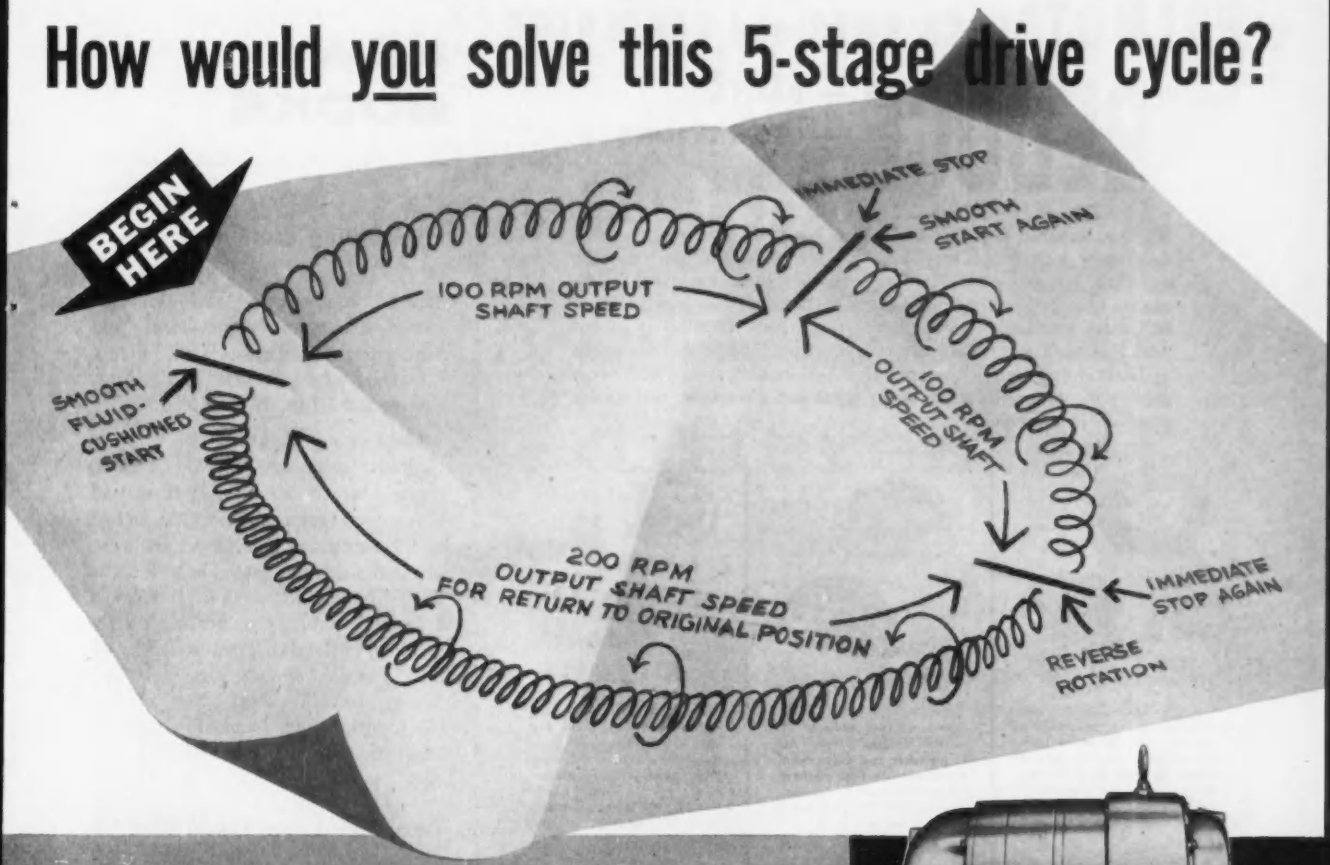
The Trifilar Pendulum and Its Application to the Experimental Determination of Moments of Inertia

A **trifilar pendulum** consisting of a platform suspended by three wires may be used to determine the moment of inertia of an object by measuring the period of oscillation of the platform when the object is placed upon it. This paper describes the pendulum and derives the equation for the vibrating system. Accuracies obtainable are discussed, together with various features of operation, including an electric timer which has been developed for use with the pendulum.

The paper concludes that the trifilar pendulum is simple to use, requires no special adapters, may be moved from place to place as desired, and gives results to a reasonable degree of accuracy.

Abstracted from, "The Trifilar Pendulum and Its Application to The Experimental Determination of Moments of Inertia," by G. W. Hughes, Sandia Corp., Albuquerque, New Mexico, The American Society of Mechanical Engineers Paper No. 57-SA-51, presented at the ASME Semi-Annual Meeting, San Francisco, Calif., June 9-13, 1957.

How would you solve this 5-stage drive cycle?



This one *modern* Reuland power package *does* all five!

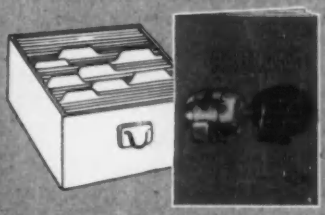
Today's ingenous, automatic machines have demanded a whole new concept in electric motors. No longer will "just any motor do" because the motor now becomes merely an integral part of the modern drive *package*.

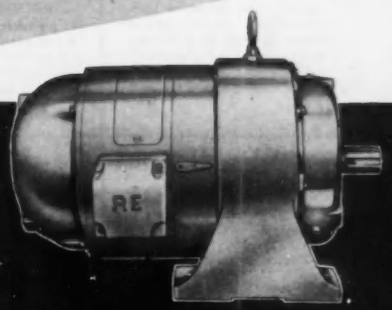
Reuland's "Xpandable Design" idea *originated* this modern new approach several years ago. With this unique system, drives incorporating many varied factors are supplied as a single unit . . . *tailored to the needs of each individual customer*.

Modern Reuland Power demonstrates every day that there *is* something new in electric motors. Whether *your* own drive needs are more complicated, or less, than the above sketch . . . it will pay you to take stock and compare with what Reuland can offer.

Our New General Catalog Will Come In Handy — Sent FREE On Request

Gives details on Reuland's "Xpandable Design" . . . also shows how O.E.M.'s save money by using Reuland's free "Special Motor Library." Get a copy for your files now, for sure.





MODERN REULAND POWER

This unit contains an internal fluid coupling . . . a two-speed reversing duty motor . . . gear reducer . . . and magnetic brake mounted between the reducer and the fluid coupling. It is typical of the literally hundreds and hundreds of tailored adaptations available as a result of Reuland's modern "Xpandable Design" idea.

It is easy to see how this one, compact drive package saves costs and space and weight in comparison to installing separate drive units.

MODERN POWER FOR MODERN-DAY PRODUCTS

REULAND MOTORS

RE*

REULAND ELECTRIC COMPANY

WESTERN DIVISION: Alhambra, California
EASTERN DIVISION: Howell, Michigan
DISTRIBUTORS IN ALL PRINCIPAL CITIES

* REGISTERED TRADEMARK

PALNUT® LOCK NUTS and FASTENERS

REDUCE — PARTS — OPERATIONS — COSTS

Spring-tempered steel PALNUT Lock Nuts and Fasteners cost less than other lock nuts and locking devices—less than plain nuts, in most cases. A single PALNUT replaces two, three, even four fastening parts according to application and type used, thus fewer parts to buy, stock and assemble. Simplified, high speed assembly is gained with PALNUT magnetic sockets, shanks and applicators which pick up, start and tighten in one operation. Self-locking spring grip keeps parts tight under vibration. Many types and sizes offer savings for products in every field.

REGULAR TYPE

Self-locking hex nuts securely fasten wide range of light assemblies. Require only 3 screw threads. Save weight. Also used on top of ordinary nut for vibration-proof fastening of assemblies.

WASHER TYPE

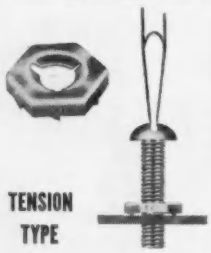
One-piece lock nut and flat washer replaces ordinary nut, lockwasher and flat washer. Many variations for mechanical and electrical assemblies. Available with bonded-in plastisol sealer.

SELF-THREADERS

Form deep, clean threads on unthreaded studs, rivets and rods while tightening. Save threading costs. Provide strong, vibration-proof assemblies. Fast assembly with standard tools. Remove and re-use on same studs.

ACORN TYPE

Pleasing dome shape covers rough screw ends, dresses up products, keeps parts tight. Also semi-acorn type with prevailing torque anywhere on threads. Very low cost.



TENSION TYPE

Simplifies adjusting screw assemblies. Nut is tightened once, never touched again. Use only screwdriver to adjust screw. Positive grip.

PUSHNUTS® for unthreaded studs, rods and rivets.

Simply push on, they lock with powerful grip. Save threading, notching, cotter pins.

WING TYPE

Lock securely when finger tightened, stay tight in service, easily removed when finger released. Cost less than ordinary wing nuts.

Write for literature and free samples of any type PALNUT Lock Nut, stating application and size. Consult our fastening engineers on any assembly problem.

THE PALNUT COMPANY
65 Glen Road, Mountainside, N. J.
Subsidiary of United-Carr Fastener Corp.
Canada: P. L. Robertson Mfg. Co., Inc., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS PAL®

Quick, secure fastening at low cost

NEW BOOKS

Engineering Economy

H. G. THUESEN, *Head, School of Industrial Engineering and Management, Oklahoma Agricultural and Mechanical College,* 6 x 9 *in.*, 581 *pp. Published by Prentice-Hall, Inc., Englewood Cliffs, N. J.* $6.95.

Engineering is utilitarian with its ultimate purpose profit. Income, capital, return on capital, taxes and other operating costs are vital factors in the successful practice of engineering and management. These are the basic elements covered in this book.

Individual chapters include discussions of interest, depreciation, estimates and engineering economy studies, various fixed and variable costs, accounting, break-even, and income taxes, to mention a few.

Two-Way Logarithm Table

RAGOT and LACROIX. 6x9 *in.*, 8 *pp, paperbound. Available from Chas. L. Ragot,* 177 *Grand Ave., Rutherford, N. J.* $0.35.

Any five-place logarithm or antilogarithm can be obtained by direct reading off this pair of graduated scales. Logarithms have been plotted above a 44-ft line with equivalent antilogarithms below the same line. The scale has been folded to fit on six pages. A large book compiled by the same authors, "A Graphic Table Containing Logarithms and Antilogarithms," has a similar table readable to six places.

Proceedings of the Second RETMA Conference on Reliable Electrical Connections

9¼ x 6¼ *in., paperbound,* 103 *pp. Published by Engineering Publishers, GPO Box* 1151, *New York* 1, *N. Y.* $5.

Proceedings of the 2nd RETMA Conference on Reliable Electrical Connections, sponsored by the Radio-Electronics-Television Manufacturers As-

(Continued on page 203)

1/8-INCH made a whale of a difference

Designed for you... the motor buyer... an entirely new motor shaft, that assures longer life, more dependable motor power for your laundry equipment product.

This new 5/8" shaft reduces bearing wear... provides rapid heat dissipation ... greater load-carrying capacity... lower average noise level... reduced end play, and practically stops end-play "growth".

Just another reason to always specify Emerson-Electric Custom-Engineered motors! WRITE TODAY for complete details...
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Shaft (left) is now being replaced by new-design 5/8" shaft (right) in all Emerson-Electric Motors for laundry equipment.

EMERSON-ELECTRIC of St. Louis

LIVE BETTER ELECTRICALLY

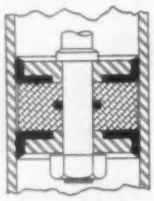
since 1890

Redesign

with

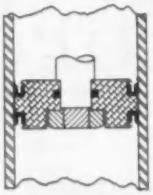
PALMETTO® U-RING

for
low cost
and
low friction



BEFORE

. . . double acting piston assembly with standard molded cup packings.



AFTER

. . . same application using PALMETTO U-Ring.

Engineers designing hydraulic and pneumatic cylinders are finding that PALMETTO U-Rings permit the use of low-cost, one-piece pistons in place of expensive, multi-part designs, with no sacrifice of efficiency. In fact, the one-piece piston with PALMETTO U-Rings is superior because it cannot loosen up, is easily assembled and serviced, and saves weight and space.

PALMETTO U-Rings seal with extremely low friction because they float freely in the packing groove. There is no opportunity for binding due to overcompression. Synthetic and fabric reinforced compositions in similar sizes allow interchangeability for high or low pressure service. The PALMETTO U-Ring is doing an exceptional job in the hydraulic equipment of many well-known manufacturers. Ask us how it can be used in your piston design to cut costs.

Rugged rectangular design PALMETTO U-Rings increases stability and eliminates rolling in the groove. Wide-lipped flare makes it suitable for use in cylinders made from commercial tubing honed up to .030 over nominal sizes.

For information on other PALMETTO packings and how they can help you simplify your design, please write.

packing more performance into every application

PALMETTO Packings

GREENE, TWEED & CO.

NORTH WALES, PENNSYLVANIA

PIP® PINS

industry's most versatile fasteners

"L" type head style

"T" type head style

"B" type head style

There is a PIP pin for every design requirement where the fastener must be self-locking for safety, yet have a quick-release feature for easy removal. PIP pins do away with bolts, nuts, cotter keys and other retaining devices in applications where parts or assemblies are subject to disassembly or removal for service or replacement . . . also as safety fasteners for preventing accidental or premature release of movable assemblies. PIP pins speed servicing of assemblies . . . permit quick interchange of mechanical units . . . allow fast assembly of portable equipment.

PIP PINS ARE FAST-SAFE-ALWAYS DEPENDABLE

Leading design engineers specify PIP pins—the original Quick-Release Pin—for the most reliable combination of speed and strength. Safetying is automatic!

Single acting PIP pins are available in "Button" head, "T" head and "L" head styles . . . in diameters to fit nominal holes from ¼" to 1". Your design requirements can be filled better by a self-locking, quick-release fastener . . . the *better* fastener is a PIP pin!

Use the technical knowledge of our Engineering Staff to find a successful solution to your quick-release fastening problem.

Send for **FREE** *illustrated* **PIP** *pin brochure No. ADI 1268. Write today!*

AVIATION DEVELOPMENTS INC.

210 South Victory Boulevard • Burbank, California

Manufacturers of Double and Single Acting **PIP** *Pins*

Sales offices in principal cities

sociation and the Dept. of Defense Advisory Group on Electronic Parts, held on Sept. 11 and 12, 1956, with the cooperation of the University of Pennsylvania. It contains papers by 13 authorities with supplementary data and information from 23 other experts. The subject matter includes: soldered connections, solderless connections, brazed connections, ultrasonic joining, equipment and tools, fluxes, surface qualities, soldering to printed wiring boards, contamination, solderable wire coatings, operator influence, and reliability evaluation.

Prevention of Mechanical Vibrations in Electronic Chassis

PB 121564, by W. F. Stokey, C. F. Zorowski, *&* F. C. Appl, *Carnegie Institute of Technology, Dept. of Mechanical Engineering, Pittsburgh, Pa., 8½ x 11 in., 90 pp. Report prepared for Rome Air Development Center. Obtainable from the Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C., $2.50.*

If an electronic chassis which is not mounted on vibration or shock isolators is subjected to a vibration that has the same frequency as a natural frequency of the chassis, a resonant vibration of the chassis will occur. Under these conditions forces on the components may become large enough to cause failure of the components or mounting hardware. Also, positions of the electrical components may change enough to cause failure of connecting wires or soldered joints. If shock and vibration isolators are not properly designed and selected, such isolators may give no protection, or may actually make matters worse. For maximum protection it is desirable to have the proper relation between the natural frequency of the chassis, and the natural frequency of the chassis-isolator assembly, the usual practice being to have it above this frequency. However, it is not desirable to have the natural frequency of the chassis higher than is necessary to protect it against resonant vibrations, since any flexibility will give protection against shock blows.

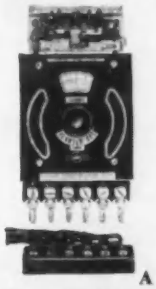
This manual describes a method for computing the lowest natural frequency of vibration of an electronic

(Continued on page 205)

for time and sequence control in automatic machinery . . .

atc

BUILDING BLOCKS for MACHINE AUTOMATION

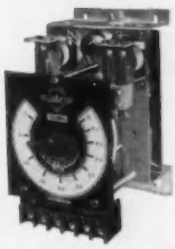


A

STOP CYCLE DIAL TIMERS

for accuracy . . . flexibility . . . instantaneous reset

Any one of 8 contact circuits are manually selected on the job by adjusting color coded slides. Split-division setting with Vernier. Rated at 25 amps, 115 volts a-c. Repeat accuracy: ⅛ of 1% of range. "Vernier Set"—13 ranges from 0-15 sec. to 0-60 hrs. "Cycle Progress"—10 ranges from 0-120 sec. to 0-60 hrs.

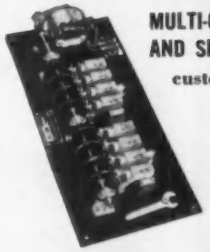


B

Printed Circuit ELECTRONIC TIMERS

for intervals from .02 to 30 seconds

Direct time setting dial. Intervals unaffected by normal line voltage changes, vibration, tube age, high humidity or temperature changes from 0-100°F. Available with remote dial.



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MULTI-CIRCUIT PROGRAMMERS AND SEQUENCE CONTROLS

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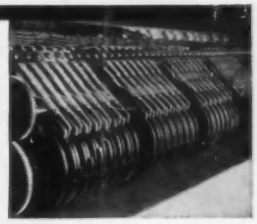
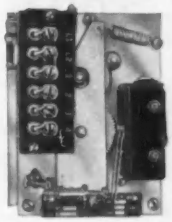


D Electric



E

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F

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Eliminate power loss . . . control full ON time as percentage of one-minute cycle to proportion power input to load demand. Rated at 25 amps, 115 volts, a-c. Standard ranges: 15, 30, and 60 sec.

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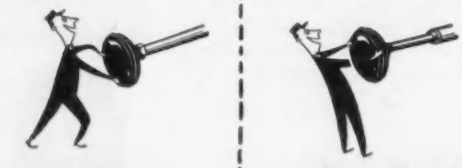

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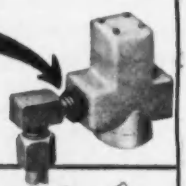

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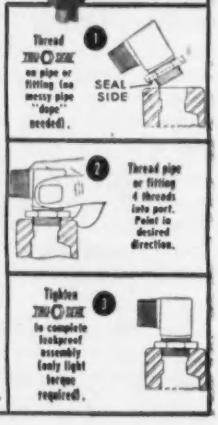
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Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

chassis that is constructed of a flat plate with the edges turned down and fastened to form a box, on which the various electrical components are mounted.

The calculations described in this manual are based on the work of Lee and Saibel, who consider only "point masses", the effect of the rocking of the mass that occurs during the vibration not being included. In Appendix A the equation developed by Lee is extended to include this rocking effect. The result of adding this effect is to add additional constraints to the system, so that in the final equation the mass of a weight acts as a constraint, and the moments of inertia in each of two directions act as additional constraints. In certain problems it is necessary to consider a spring to be acting on the plate, and the manner of doing this is included in the development.

Maintenance Engineering Handbook

Edited by L. C. Morrow, *Consulting Editor of Factory Management & Maintenance,* 9 x 6¼ *in., approx. 1000 pp. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y., $20.*

The whole field of modern maintenance engineering is covered in handbook form. Fundamentals and procedures essential to uninterrupted industrial production at lowest cost consistent with quality of product are given.

Included is a practical discussion of the technicalities of the upkeep of buildings, mechanical, electrical, and servicing equipment. Also covered are such problems as stores and their control, lubrication, instruments, sanitation, welding, and corrosion.

In addition, the management end of maintenance is fully covered, including organization of maintenance personnel, training, planning of work, project control, and costs and budgets.

The scheme of other engineering handbooks in presenting descriptions of fundamentals, methods, equipment, and materials, many reference data, and profuse illustrations is followed—all being prepared by 75 specialists in the various phases of maintenance engineering.

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* Are attached in a split second by resistance welding
* Are *fused* to the parent component . . . can't be shaken loose
* Facilitate final assembly because they're permanently positioned.

And, in addition, RN nuts eliminate costly extra steps such as extruding and tapping, drilling and tapping, and require no retapping.

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In a split second without metal filler or fluxes!

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Feed nut manually or automatically

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Position product component between electrodes

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Activate welder

The RN nut's many advantages to production and the product improvements it enables . . . neater exterior lines, extra operating space for working parts, flush surfaces and new design possibilities . . . deserve careful consideration. Write for more information today.

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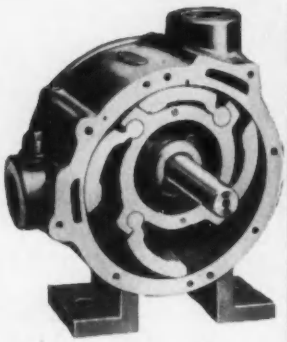

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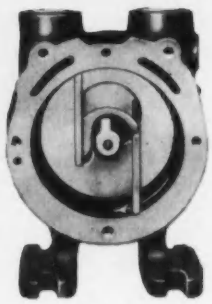

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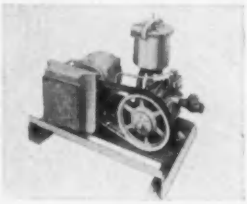

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OUR READERS SAY . . . . . .

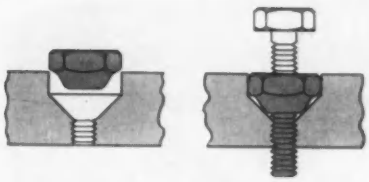
Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

New Fastening Method

To the Editor:

I found the articles on "20 Tamper-Proof Fasteners" (July '57, p 176) and "Fastening Studs to Plates" (March '57, p 194) included several solutions that were new to me. I came across a similar fastening problem when searching for a method to prevent a set screw from turning after being adjusted to its correct position. This was in conjunction with a Navy Bureau of Ordnance contract.

The way I solved it was to drive a standard locknut upside-down into a hole 1/32 in. smaller in diameter than the minimum diameter of the nut. After the nut was set, the set screw was threaded through the nut and into the tapped hole. The nut may be



forced up slightly as the screw engages the tapped threads. The previous design used a standard nut with a jam nut. The new method is not only more economical, but also takes up less space. —Wadsworth W. Mount
Summit, N. J.

Ed—Looks good from here. More data on lock nuts will appear in the next Design edition, Sept 30 in "Design of High-Temperature Bolted Assemblies."

Prime Number Table

To the Editor:

Factor tables contained in my recent book, *Calculation of Change Gear Ratios*, are a possible addition to List A in "Mathematical Tables" in the July issue page 183. This book includes prime number tables for all numbers

(Continued on page 209)

A NEW FREEDOM IN BEARING APPLICATIONS

Availability of Sintered Powdered Metal Bearings and machine parts from a fully competent and technically responsible source opens the way to improvements in mechanical products.

Bunting facilities for designing, engineering and manufacturing of Sintered Powdered Metal Bearings and parts are as comprehensive and responsible as the traditional Bunting competence in the field of Cast Bronze Bearings.

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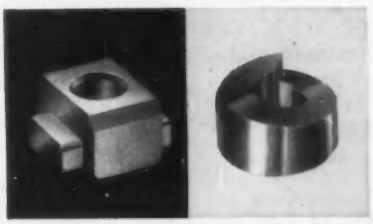

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the positive locking pin with quick release

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Whenever units are frequently assembled or disassembled the Ball-lok unique principle assures fast, safe and dependable operation. Approved by leading engineers in all phases of electronic, aircraft, commercial and military plants.

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For wider design acceptance, speed of assembly and economy of servicing – specify *Ball-lok pins*. Available in most diameters and lengths to usual bolt standards or manufactured to your specifications.

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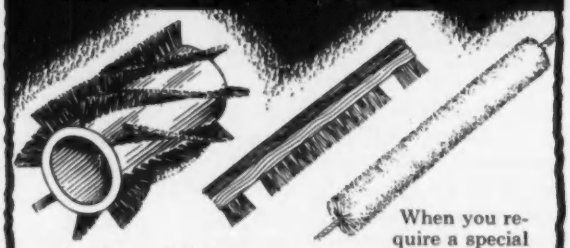

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up to 100,000, as well as other tables useful in selecting gear ratios.

—ERIC H. WANG
Albuquerque, N. M.

Ed—Mr. Wang's book was reviewed in *Product Engineering* (Nov. '55) as well as in *Design Digest*, (Mid-Oct. '56, p. D74) and is available at $3.50 from the author at 706 Loma Vista Drive, Albuquerque, N. M. Another book, *Two-way Table of Logarithms* by Ragot and Lacroix is reviewed in this issue, page 200.

Brocot's Tables

To the Editor:

In the July issue, the bibliography on mathematical tables by Charles R. Sexton makes no mention of Brocot, who about a century and a quarter ago came out with *Brocot's Tables*, the first book or table of decimal equivalents of fractions. Because they are useful in calculating change gearing, we publish such a list in *Tables of Decimal Equivalents of Fractions* along with several other tables of value in change gear calculations.

—GRANGER DAVENPORT
Gould & Eberhardt

Ed—References to Brocot certainly are obscure. However, he did publish tables during the 19th Century. G & E's book is available for $1.50

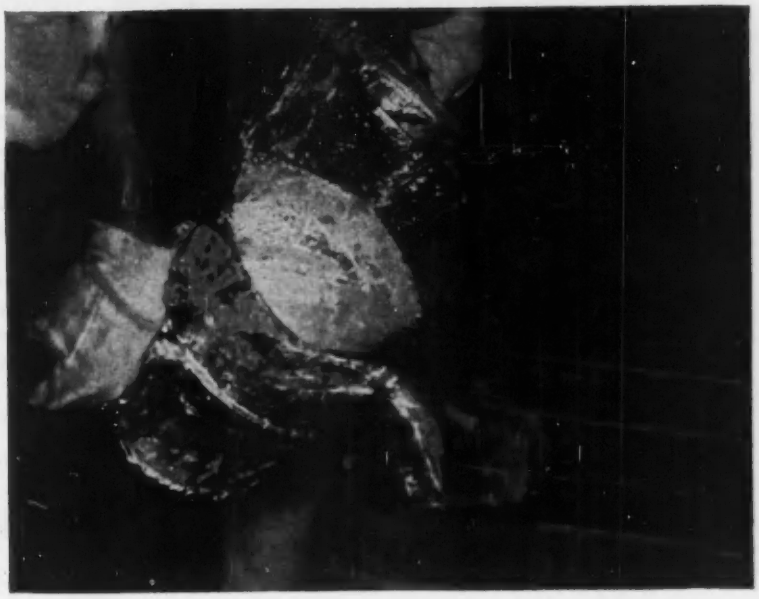
Never Too Old To Learn

To the Editor:

There was a boy who thought he'd like
to be an engineer.
He studied long and hard to bring
about his dream career.
He worked his way through college,
cramming hard for his degree.
And after years of tough exams . . .
emerged triumphantly.
Now engineering jobs, that year,
were difficult to find.
And industry, aware of this,
was not prone to be kind.
But since our budding engineer
was desperate for work,
He took a job equivalent to
a junior stock room clerk.
It wasn't very easy though
to bring himself to see,
Quite why his wife was earning just
about as much as he.
The years went by from forty-nine

(Continued on page 211)

Do you hear meaningless claims when you buy self-aging Aluminum Alloys?



Federated Tenzaloy is the most widely used of all high-strength, self-aging aluminum alloys because it has the highest yield strength, and it has the best all-around combination of properties. Yield strength is the true measure of a metal's ability to take punishment, regardless of other claims that are made.

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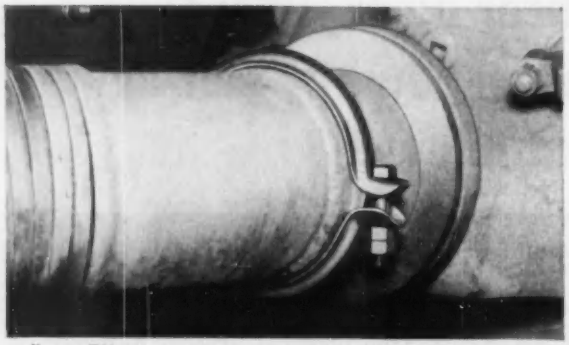

Marman JE61 Joint connecting an exhaust manifold and stack on a diesel engine.

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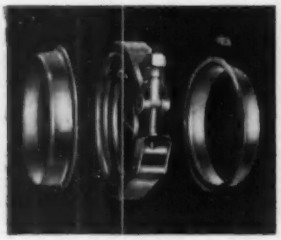
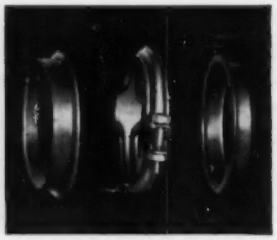
For Quick Assembly and Disassembly of Tubing, Ducting, Piping

Marman J60 Series Joints are designed for standard and thin wall tubing, piping and ducts in automotive, chemical, industrial and marine applications. Assembly and disassembly is quick and easy, with a "quick coupler" latch or simple bolt fastening. J60 Joints are available in stainless or mild steel, with a choice of fuel-resistant, synthetic or silicone rubber gaskets. Sizes from 1" to 12". Send for Bulletin L-255-602.



Marman stainless steel JQ Joint with quick coupler latch.



Marman mild steel JE Joint with simple bolt latch.

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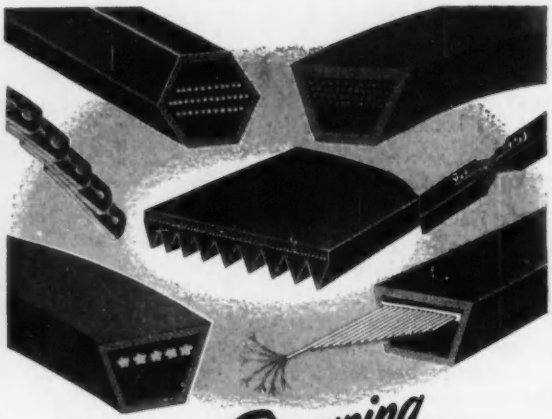

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are rated par with him!
What did he do? His choice was small,
but he's nobody's fool.
He quit his job in industry . . .
enrolled again in school!

—Bob Marie
Bakersfield, Calif.

Its reprinted from *Indiana Technician.*

3-D Photoelastic Equation Corrected

To the Editor:

In my article on "Three-Dimensional Photoelasticity" (July 57, p. 135) I incorrectly stated the equation (p 140) for the equivalent stress as:

$$2\sigma_e^2 = \left(\frac{f}{t}\right)^2 (n_x^2 + n_y^2 + n_z^2)$$

$$\sigma_e^2 = \left(\frac{f}{2t}\right)^2 [n_x^2(2 + \mathrm{Sin}^2 2\theta_x) + n_y^2(2 + \mathrm{Sin}^2 2\theta_y) + n_z^2(2 + \mathrm{Sin}^2 2\theta_z)]$$

where n_x, n_y, n_z denote the fringe orders for the three-cube direction

(Continued on page 213)

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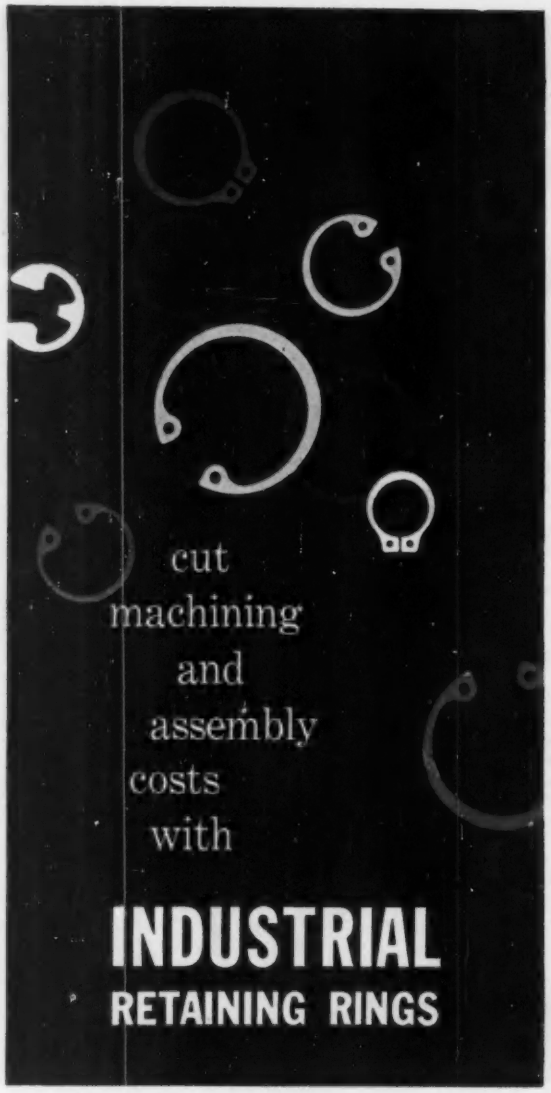

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using circularly polarized light; $\theta_x, \theta_y, \theta_z$ denote the isoclinic angles for the three directions of light incidence using plane polarized light; f is the fringe value of the model material, and t is cube thickness. —M. M. LEVEN
Pittsburgh, Penn.

Wrong Definition

To the Editor:

Recent reference to your article, "How You Can Measure Air Flow," (June 57, p 145) has led me to believe that the velocity formula (Formula 5, p 149) is in units of ft per min, not ft per sec as defined several lines below the formula. The value of Q (Formula 5, p 149) would also have to have velocity in units of ft per min, so as to coincide with your earlier definition of Q in cfm and A in sq ft.

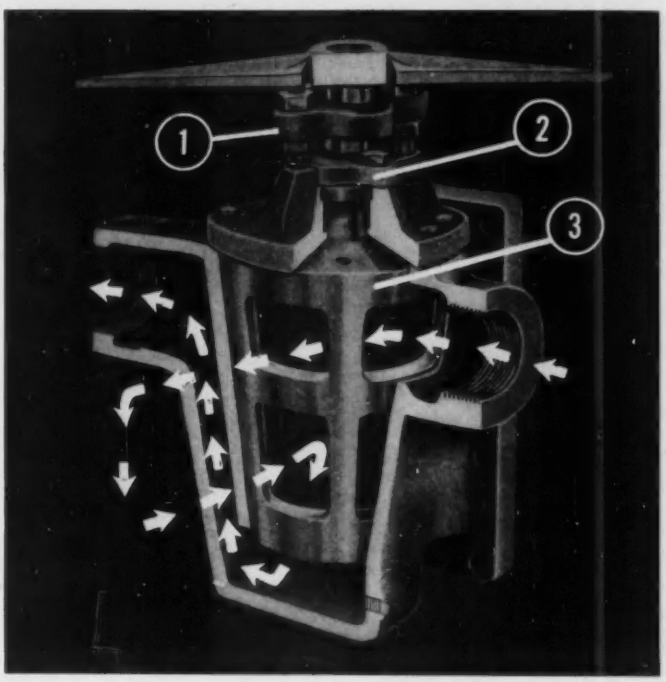
Principles presented in the article are of particular interest in measuring flow of evolving air in electronic computing equipment.—DAVID C. POOL
Electronic Assoc., Inc.

Ed—Your observation is correct. Please excuse the typographical error.

Correction

In preparation of Table IV of Epoxy Castings (June '57, p 138), the author inadvertently omitted Furane Plastics Inc., Los Angeles 39, Calif., as a compounder.

"That's a very critical dimension—at least they're very critical of it out in the shop."



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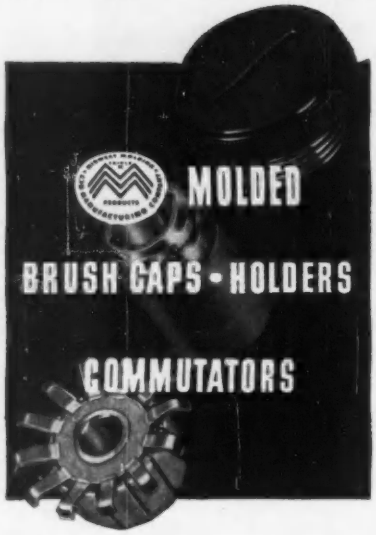

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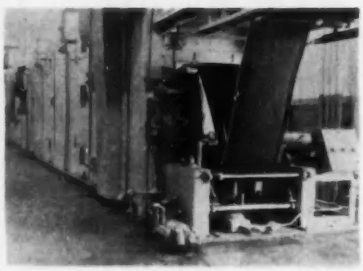

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The new plant has more than tripled the firm's magnetic-tape production capacity, and includes facilities installed, but not yet in operation, for another 50% increase.

Specialists in Bearings Problems

The Continental Bearing Research Corp., New York City, has been formed to sell engineering development and manufacturing know-how in the specialized field of bearings and lubrication. Specifically, it will analyze, design, and supply bearings—in production or semi-production quantities—for specific applications; also

(Continued on page 384)

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undertake design studies on a project or consultant basis. Stanley Abramovitz, formally with the Franklin Institute, will direct engineering.

New Divisions

Electro Mechanical Products Co., Garden City, Mich., has established a Slip Ring Div. for the development and manufacture of slip rings for aircraft, ordnance and marine purposes.

Beckman Instruments, Inc., Anaheim, Calif., has established a new Systems Div. to permit expansion of engineering and marketing programs.

Hydraulic Accessories Corp., Van Dyke, Mich., has formed a Hydraulic Valve Div.

The Cold Metal Products Co., Youngstown, Ohio, will be known as the Strip Steel Div. of the Jones & Laughlin Steel Corp.

Name Changes

Superior Hermetic Seals Co., Joliet, Ill., has changed its name to Philtrol Seals, Inc.

American Safety Razor Corp. has changed its name to A.S.R. Products Corp. to reflect the company's diversification.

North American Instruments, Inc., Altadena, Calif., has changed its name to Northam Electronics, Inc.

Automatic Temperature Control Co., King of Prussia, Pa., has changed its name to Automatic Timing & Controls, Inc.

Motion Pictures

All films are 16 mm, in color and with sound unless otherwise noted.

Aluminum Finishing—15 min. Demonstrates aspects of aluminum finishing from pre-cleaning to final assembly. Loaned free by Turco Products, Inc., Los Angeles, Calif.

Hold It—12 min. (black and white). Describes application of blind rivets to aircraft structures. Available from Huck Mfg. Co., Detroit, Mich.

The Leading Role—25 min. Structural advantages, manufacture, fabricating methods and uses of welded steel. Available from the Formed Steel Tube Institute, Cleveland, Ohio.

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ADVERTISEMENT

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

BEARING FITS AND FITTING PRACTICES

As shown in *Fig. 1*, the fitting of Micro-Bearings, like the fitting of larger ball bearings, chiefly involves the clearances between the inside diameter of the housing and the outside diameter of the bearing; the bore of the bearing and the shaft diameter.

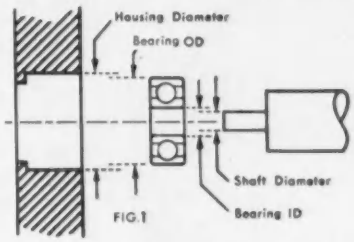

FIG.1

The achievement of the desired fit by dimensioning is illustrated in *Fig. 2*. The bearing ID is represented by the top blocks and the shaft OD is represented by the lower blocks. Such a block diagram could also be applied to housings and bearing outside diameters. In this block diagram, it will be noted, the bearing ID is represented by a .00015 tolerance with a similar tolerance for the shaft. A resulting fit of line to line to .0003 loose is shown.

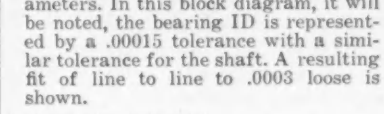

FIG.2

An interference fit not tighter than line to line is suggested for the following reasons:

1. *Difficulty in assembly.*
2. *Difficulty in disassembly. This is often more hazardous than the assembly operation and may result in total bearing destruction.*
3. *Reduction in radial play.*
4. *Danger of bearing ring conforming to possible poor geometry of mating shaft or housing.*

TOLERANCE DISTRIBUTION

The maximum .0003 loose condition shown in *Fig. 2* may be excessive in some applications. The fitting problem then resolves itself to reducing this extreme, and yet maintain the maximum tight fit of line to line. The looseness may be reduced by redimensioning the shaft to .12490/.12475 as shown in the block diagram, *Fig. 3*.

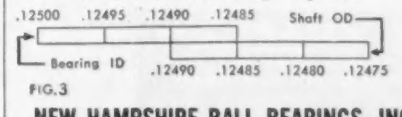

FIG.3

If the frequency distributions of shaft and bearing ID sizes were statistically normal, the modal fit of all parts would be 0.0001 loose. Accordingly, an insignificant percentage of parts would be mated to the extreme values, and for practical purposes could be ignored.

With regard to bearings' outside diameters and bores, however, normality of the distribution curve cannot be assumed. During the grinding operation, the "most metal tendency" tends to skew the frequency distributions for bearing ID's and OD's in the direction of most metal.

In grinding and finishing shafts and housings, similarly skewed distributions occur.

Operating on a modified probability distribution of tolerance is possible if the volume of parts is sizeable. But the approximate distribution of shaft and housing sizes must be verified if this method is to be used.

MATERIALS and SURFACE FINISHES

The ease of assembly is also affected by materials and finishes. The following factors must be considered:

1. *The galling characteristics, hardness and ductility of the materials involved.*
2. *Finish lay patterns produced by various tools and techniques used.*
3. *R M S surface finish values achieved.*
4. *Geometry of shafts and housings as regards out-of-roundness, taper, etc.*

The possible combinations of these elements in any single application are so numerous that their gross effect can only be ascertained by trial and error, or by a detailed study of operations on individual applications. A more complete discussion of fitting practices, including sizing methods and coding, is found in our design handbook.

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If you work with miniature bearings, you'll find this new, 70 page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

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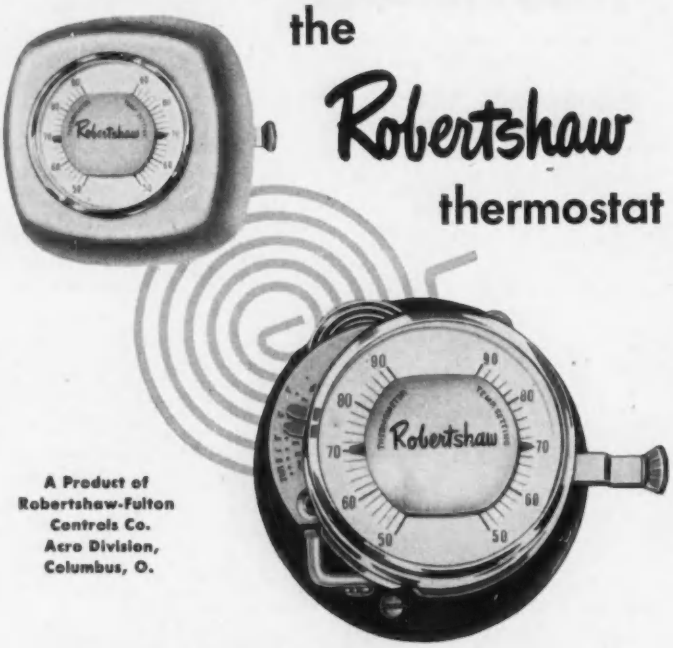

A Product of Robertshaw-Fulton Controls Co. Acro Division, Columbus, O.

The Robertshaw TR125 Room Thermostat is a two wire low voltage thermostat designed for *long life* and *dependable* service, so Robertshaw insists on PROVEN PERFORMANCE before it is sent to a customer. In addition to observing rigid manufacturing specifications and making frequent inspections, the company tests each part before assembly, then follows with 100% final inspection and a test under actual field operating conditions. As for the finished product, it has an easily-read double dial, *positive* temperature adjustment and a completely enclosed dust-tight precision switch assembly and requires no leveling.

Robertshaw's high standards are fully met by precision Chace Thermostatic Bimetal. The spiral actuating element is coiled from strip processed by Chace to the closest tolerances available in the industry. A smaller coil under the Robertshaw name plate indicates the room temperature. Both are typical of the top quality bimetal produced by Chace, manufacturers of thermostatic bimetal exclusively for over a third of a century.

If your device indicates or controls temperature or protects from effects of heat or cold you may need the precision actuation of Chace Thermostatic Bimetal, available in 28 types, in strip, coil or in fabricated elements of your design. We do not manufacture complete controls or any other devices in competition with our customers. Write for 44-page booklet "Successful Applications of Thermostatic Bimetal", containing many pages of valuable engineering data.

IT BINDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1607 BEARD AVE., DETROIT 9, MICH.

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api a brand new name . .

for the same old skill

We haven't made a button in years. Since the early 1920's we've molded precision plastic parts for the automobile industry, the business machine industry, for industry in general. So we've changed our name from Auburn Button Works, Inc. to Auburn Plastics, Inc. We're part and parcel of the plastics industry—one of the greatest and most dynamic arrivals on the American industrial scene.

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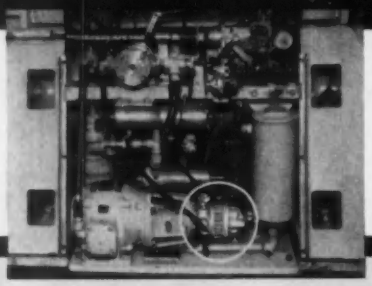
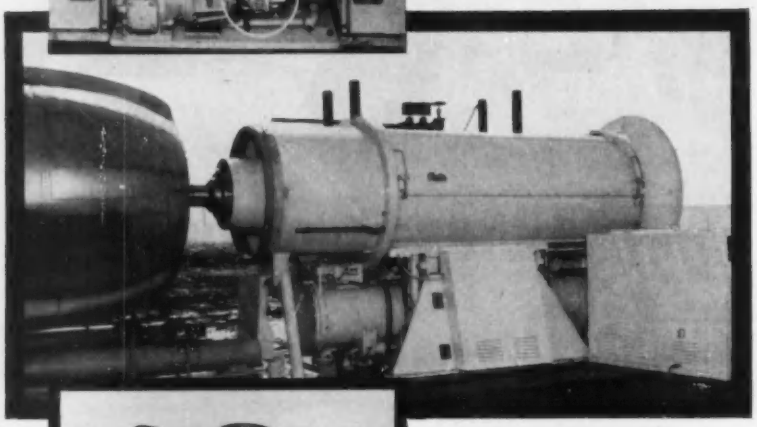
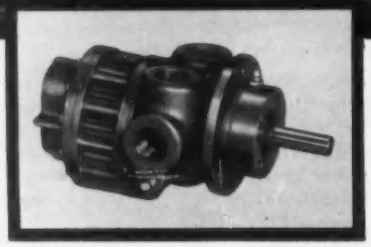
for Efficient Operation of Engine Test Stand



NERVE CENTER OF THE UNIT

Oil used as the power absorption medium in this dynamometer is supplied to the inlet control valve by a Roper Series F Pump. Four other Roper pumps are integral for pressure lubrication and hydraulic actuation of this unit.





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GEO. D. ROPER CORPORATION
379 Blackhawk Park Avenue
Rockford, Illinois

ROPER Rotary Pumps

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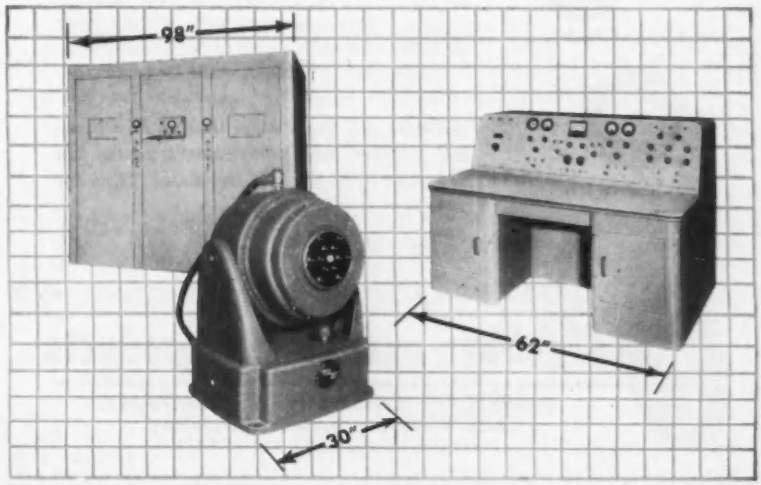

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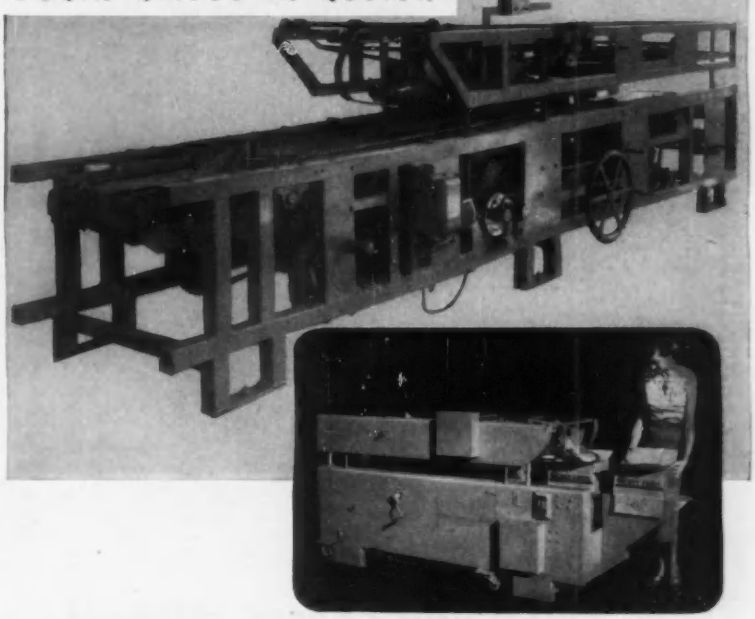
chain drives in action



speed cases through sealing machines

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here's how chain drives can work for you...

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For the full story on the Cullman power transmission line — roller chains, sprockets and flexible couplings, write today for catalog No. 51, or see your local Cullman Distributor.

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ROLLER CHAINS AND SPROCKETS

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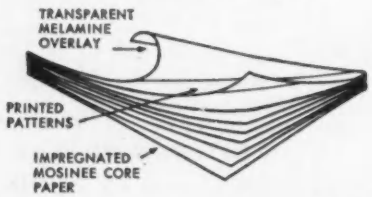

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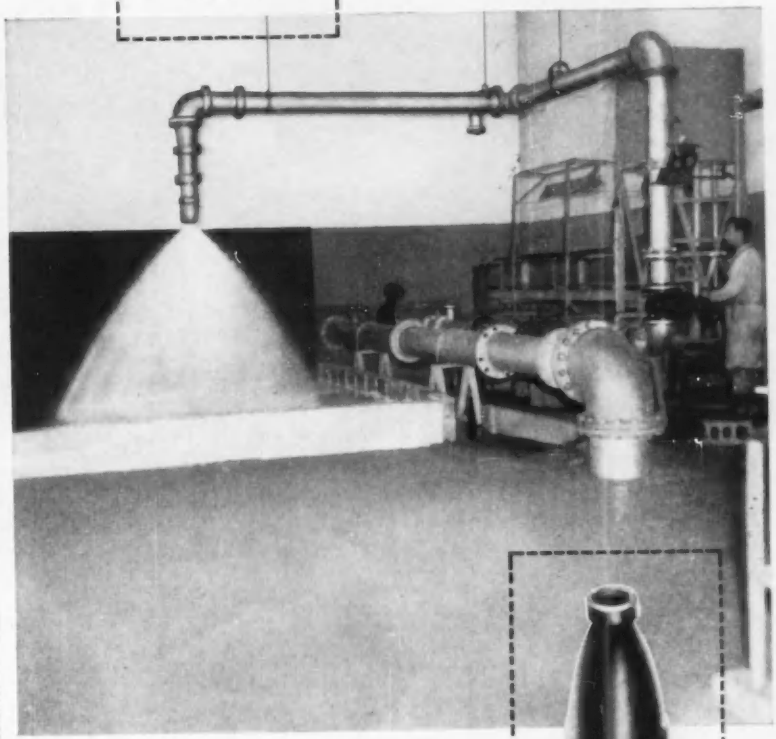

Performance test in one of the country's largest hydraulic laboratories. 6-inch Spraco full cone nozzle spraying 720 GPM at 10 lbs. pressure. Spraco performance data on all types of nozzles is extremely comprehensive and accurate. Inset shows a 1½-inch full cone nozzle.

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full cone spray nozzles

IN STOCK — the most complete range of sizes and capacities available anywhere.

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FLAT SPRAY and HOLLOW CONE SPRAY nozzles are also available from stock.

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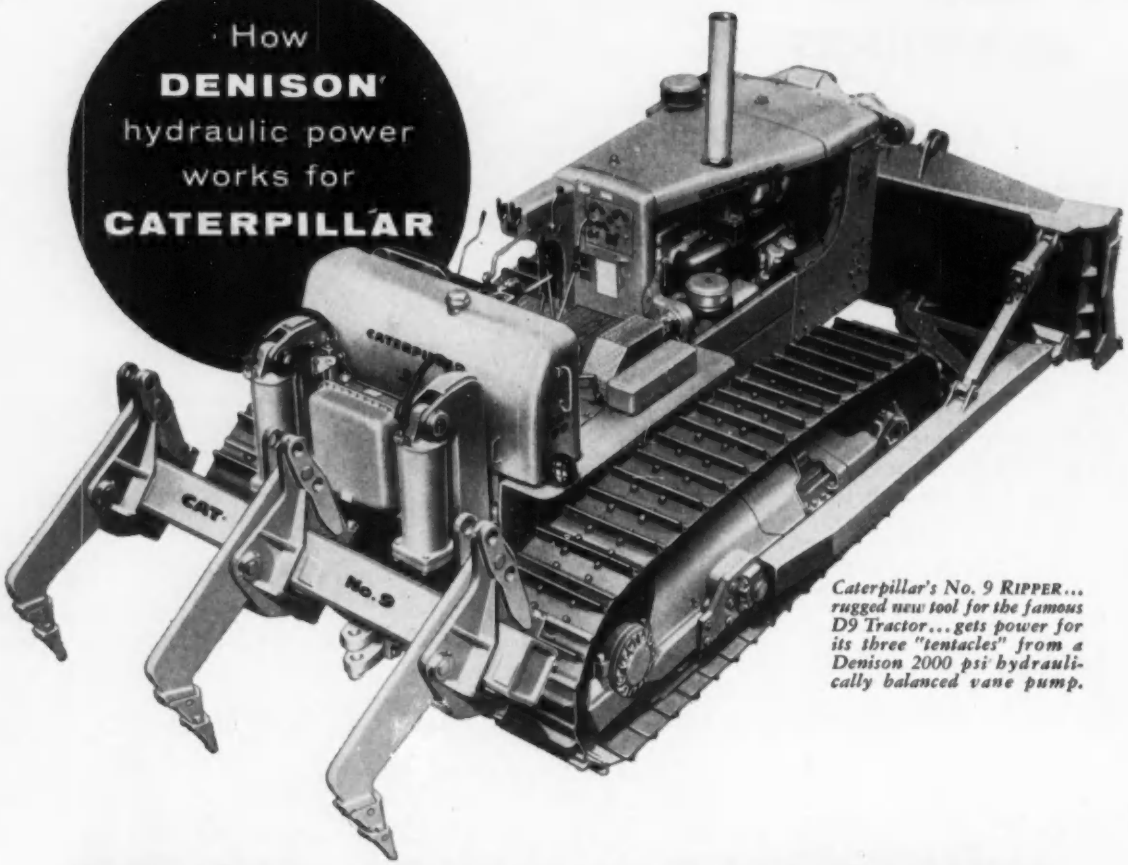
How **DENISON** hydraulic power works for **CATERPILLAR**



Caterpillar's No. 9 RIPPER... rugged new tool for the famous D9 Tractor... gets power for its three "tentacles" from a Denison 2000 psi hydraulically balanced vane pump.

PUTTING TEETH IN THE "RIPPER"

...another application for DENISON hydraulic power

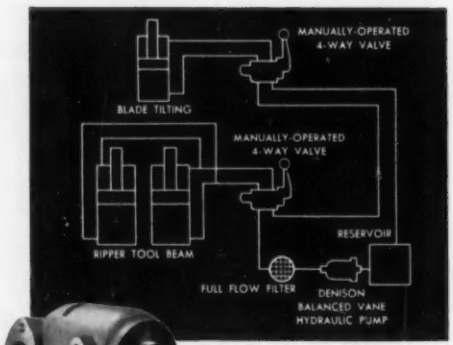
Caterpillar's rugged No. 9 Ripper—newest tool designed for their powerful D9 Tractor—proves again the basic design advantages of Denison's 2000 psi vane-type hydraulic pump.

The Ripper's three working shanks are powered by the Denison "T" series pump—capable of delivering up to 2000 psi continuously. Driven by the engine power take-off, the Ripper's pump actually operates at 1450 psi (relief valve setting) which provides generous reserve stamina to withstand heavy workloads with no danger of breakdown. With the Denison "T" series pump, Caterpillar designers assured the owner of cold-weather pump-starting ability without damage to the pumps. They assured speedy servicing in the field because the complete pumping cartridge is removable as a unit. It all adds up to *lower operating cost* and dependable performance.

There's less weight, less cost-per-horsepower—with smaller lines and valves with the Denison 2000 psi pump as the heart of a hydraulic system. Design flexibility is unlimited.

Have your Denison hydraulic specialist tell you more about the 2000 psi pump—and help you with any equipment or machinery design problem. Write Denison Engineering Division, American Brake Shoe Co., 1194 Dublin Road, Columbus 16, Ohio.

DESIGNERS—ENGINEERS! New Bulletin 201 describes "How to Design More Efficient Hydraulic Power Into Mobile Machinery." Write us.



Circuit drawing illustrates hydraulic system for powering Caterpillar's new No. 9 Ripper.

Denison 2000 psi vane-type hydraulic pump.

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For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 169-177.

To get more data about new Components, Materials and Parts fully described on pages 129-165, just circle the appropriate key number.

To get more information about advertised products, circle the page number of the advertisement in which you are interested. If more than one advertisement is located on a single page, letters preceding number identify each advertisement. Key: T—Top; B—Bottom; R—Right; L—Left; TL—Top left; BL—Bottom left; TR—Top right; BR—Bottom right.

For specialized data . . . prices, sizes available, nearest source of supply, etc. . . . do not circle key number but indicate your needs in the space allotted at the bottom of the card. Use this space, too, if information about a specific product among several mentioned in an advertisement is desired.

FIRST CLASS
PERMIT NO. 64
(Sec. 34.9 P.L.&R.)
NEW YORK, N. Y.

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PRODUCT ENGINEERING
READER SERVICE DEPARTMENT
330 WEST 42nd ST.
NEW YORK 36, N. Y.

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Name _____

Position _____

Company _____

Address _____

City & State _____ 9/16/57

NEW COMPONENTS AND MATERIALS . . .

Description of these new engineering materials appear on pages 129-165. Circle key number for more data

1—Self-Lubricated Bearing With Teflon-glass Liner
2—Conductive Cells
3—High-Temperature Air Motor
4—Electrical Conductor Tape
5—Remote Positioning Without Feedback Reference
6—Manual Computer
7—Dual-Speed Hydraulic Cylinder
8—Meter With Over-Range Protection
9—Pneumatic Pressure Reducer
10—Solenoid-Operated Step Switch
11—Three-way Lock Washer
12—Rotating Union
13—Internal Pinion Decimal Counters
14—Plug-in, Four-Way Control Valves
15—Tiny, Linear-Stroke Solenoid
16—High-Speed Clutches and Brakes
17—Four-Way Valve
18—Rubber-to-Metal Adhesive
19—Pilot-Operated Relief Valve
20—Subminiature Time Delay Relays
21—Compression Connectors
22—Adjustable Program Timer
23—Electronic Timer
24—Throttling Valve
25—Epoxy Resin Parts
26—Flexible Magnetic Shielding Foil
27—Ready-Mixed Aluminum Paint
28—Double-Surfaced White Tracing Cloth
29—Solenoid-Controlled, Pilot-Operated, Four-Way Valves
30—Variable Timer
31—Variable Delivery Hydraulic Pump
32—Pocket Organizer
33—Portable Tracing Unit
34—Blueprint Paper
35—Illuminated Portable Tracing Board
36—Calculator

PRODUCTS ADVERTISED

C2	1	2	4	L6	R6	8	10	11	12
13	14	15	16	17	18-9	20-1	22-3	24-5	26
27	28	29	30	31	32	33-4	35-6	37-40	41
42-3	44-5	46	47	48	49	50	51	52-3	54
55	56-7	58-9	60	62	64	66	119	120	121
124	126	128	131	133	135	137	138	139-40	141
142	143	144-5	146	147	148	149	150	151	L152
R152	153	154	155	156	157	158	159	L160	R160
161	162	163	164	165	166-7	168	169	T170	B170
171	172	173	174	175	177	178-9	181	182	183
184	185	186	187	188	189	190	191	192	193
194	195	196	197	198	199	200	201	L202	R202
203	L204	TR204	BR204	205	L206	R206	207	L208	TR208
BR208	209	L210	TR210	BR210	211	L212	TR212	BR212	213
L214	R214	215	219	220	221	222	223	224	225
226	227	228	C3	C4					

NEW COMPONENTS AND MATERIALS

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36				

NEW CATALOGS AND BULLETINS

37	38	39	40	41	42	43
44	45	46	47	48	49	50
51	52	53	54	55	56	57
58	59	60	61	62	63	64

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NEW BULLETINS . . .

listed below are described on pages 169-177. Circle key number for your copy.

37—Heat Resistant Castings, 30 pp., Alloy Casting Institute

38—Oiless Bearings, 24 pp., Arguto Oiless Bearing Co.

39—Time Saving Tips for Draftsman, Engineer, 34 pp., Frederick Post Co.

40—Heat Exchangers, 20 pp., Wolverine Tube, Div. of Calumet & Hecla, Inc.

41—Nickel Chromium Alloy, 20 pp., Hoskins Mfg. Co.

42—Surface Roughness, Waviness, Lay Standards, 24 pp., Brush Electronics

43—Digital Voltmeter Application and Data, 28 pp., Non-Linear Systems

44—Mica Selector, 2 pp., Ford Radio & Mica Corp.

45—Subminiature Connectors, 12 pp., DeJur-Amsco Corp.

46—Coiled Cords, 16 pp., Cords Limited Div., Essex Wire Corp.

47—Silicone Molding Compounds, 4 pp., Dow Corning Corp.

48—Static Seals, 22 pp., Franklin C. Wolfe Co., Div. of Parker Appliance

49—Panel Meters, 16 pp., Waters Mfg., Inc.

50—Intermediate Whiteprint Materials, 4 pp., General Aniline and Film

51—Control Units for Magnetic Chucks, 6 pp., Sundstrand Machine Tool Co.

52—Heavy Duty Terminal Blocks, 4 pp., Marathon Electric Mfg. Corp.

53—Stainless Steel Fasteners, 8 pp., Allmetal Screw Products Co., Inc.

54—Glass Fiber Tubing, 2 pp., Pacinca Laminates

55—Welded Steel Tubing Tolerances, 14 pp., Revere Copper & Brass, Inc.

56—Miniature Self-Locking Nuts, 4 pp., Standard Pressed Steel Co.

57—Hexagon Nuts, 24 pp., National Machine Products Co.

58—Stainless Steel, Hex-Socket Screws, 16 pp., Allen Mfg. Co.

59—Electronic Switch Controls, 25 pp., Arrow-Hart & Hegeman Electric Co.

60—Vacuum Impregnation, 6 pp., Western Sealant Co.

61—PVC Pipe Fittings, Flanges, Valves, 24 pp., Tube Turns Plastics

62—Transmission Products, 88 pp., Jeffrey Mfg. Co.

63—Centrifugal Castings, 8 pp., Sandusky Foundry & Machine Co.

64—Pneumatic Friction Clutch and Brake, 4 pp., E. W. Bliss Co.

PRODUCTS ADVERTISED

NEW PRODUCTS . . .

NEW BULLETINS . . .

SPECIFIC DATA . . .

PRODUCTS ADVERTISED

C2	1	2	4	L6	R6	8	10	11	12
13	14	15	16	17	18-9	20-1	22-3	24-5	26
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R152	153	154	155	156	157	158	159	L160	R160
161	162	163	164	165	166-7	168	169	T170	B170
171	172	173	174	175	177	178-9	181	182	183
184	185	186	187	188	189	190	191	192	193
194	195	196	197	198	199	200	201	L202	R202
203	L204	TR204	BR204	205	L206	R206	207	L208	TR208
BR208	209	L210	TR210	BR210	211	L212	TR212	BR212	213
L214	R214	215	219	220	221	222	223	224	225
226	227	228	C3	C4					

NEW COMPONENTS AND MATERIALS

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36				

NEW CATALOGS AND BULLETINS

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44	45	46	47	48	49	50
51	52	53	54	55	56	57
58	59	60	61	62	63	64

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about

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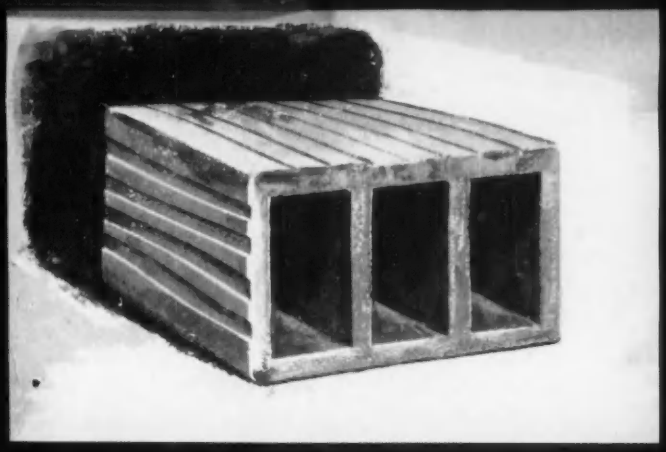
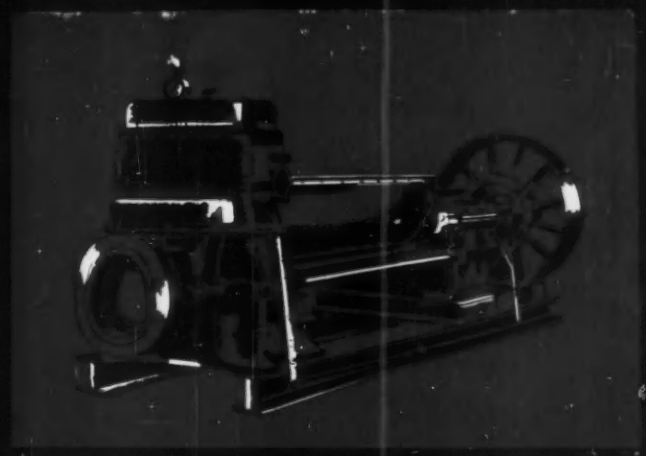
Requests for information made through *Product Engineering* Reader's Service will be forwarded to the manufacturer as quickly as we can process them. If you write directly to the manufacturer, please identify advertisement by issue and page number to facilitate reply.





No Margin for Air— No Margin for Error

ANOTHER DRIVE REQUIREMENT MEETS ITS MASTER

Yes, it's a fact—unless you remove the air from the clay, you get a no-good tile. And whether air is your problem, or not—error is always a problem. And it's never a mistake to come to Master for the right power drive. In every kind of industry, Master customized package drives give you the utmost in flexibility, compactness and performance.

Here, the primary requirement is power—and the husky, big 200 H.P. Master fills the bill year in and year out. Your requirements might be better met by integrating Master components into a single, efficient, compact unit for the right horsepower, right shaft speed and right mounting features. What are they?

A husky 200 H.P., 440 volt squirrel cage induction Master Motor powers this 14-ton De-Airing Brick and Tile Machine with a capacity of over 8000 bricks per hour. Two parallel shafts carrying pug knives work clay, pass it into vacuum chamber with auger cylinders where it is finished and discharged.

Motor Ratings	½ to 400 H.P. All phases, voltages and frequencies.
Motor Types	Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.
Construction	Open, enclosed, splashproof, fan-cooled, explosion-proof, special purpose.
Speeds	Single-speed, multi-speed, and variable speed.
Installation	Horizontal and vertical, with or without flanges and other features.
Power Drive Features	Electric brakes (2 types)—5 types of gear reduction 3:1 to 432 to 1 ratio. Mechanical and electronic variable speed units—fluid drives—every type of mounting.

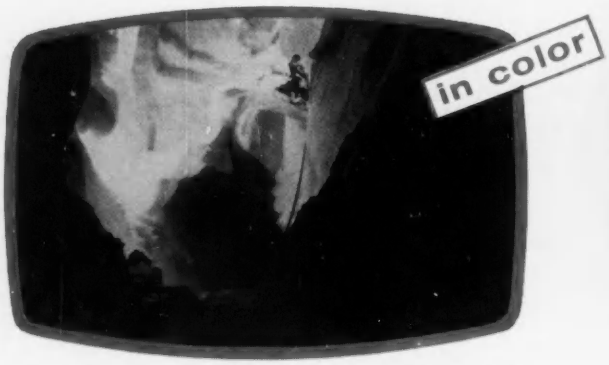
MASTER

THE MASTER ELECTRIC COMPANY

DAYTON 1, OHIO

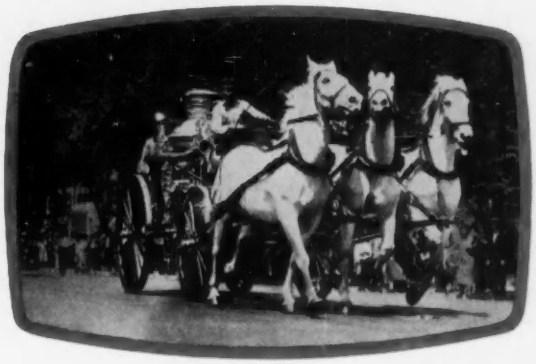
SEE TIMKEN TELEVENTS ON NETWORK TV

Two big hour-long spectaculars this fall



Over 126 NBC STATIONS, SEPTEMBER 23rd

"Eleven Against the Ice", the story of the Antarctica Turnpike. See men and machines build a trail across Antarctica's frozen wastes—in spite of 200 mph winds, temperatures of 120 degrees below zero and crevasses big enough to swallow a 20-story building. It's a triumph of engineering and human courage, a whale of a television show.



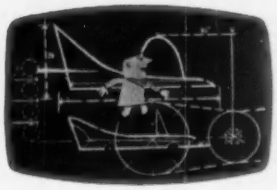
Over 142 NBC STATIONS, NOVEMBER 21st

"The Innocent Years". Recaptured from exciting old films and newsreels, you'll see happy days relived. Experience the excitement of "Teddy" Roosevelt, Thomas Edison and Mark Twain in action. Hear songs like: "In the Good Old Summertime", "He'd Have to Get Out and Get Under". Enjoy the fun of family picnics, the joys of people in the last untroubled time in our history.

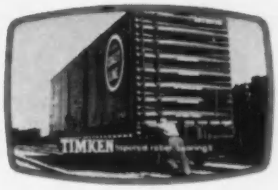
And commercials that help you sell . . .

See How man stumbled on the concept of the wheel.

See Why America's railroads have always led the world.



See Why Americans jump for the latest thing in cars.



See One man push a freight car all by himself.

Years of national and trade advertising, backed by their superior performance, have made "Timken" the best-known name in bearings—a name that helps to sell the products that use Timken® bearings. Now, network television will build even a greater awareness of Timken bearings—make them an even bigger sales plus in the equipment you sell. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN TAPERED ROLLER BEARINGS

TRADE-MARK REG. U. S. PAT. OFF.